PEER REVIEW REPORT

Lower East Coast subRegional Groundwater Flow Model and Draft Model Documentation

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Executive Summary

The South Florida Water Management District (District) commissioned a peer review of a groundwater flow model of the Lower East Coast of Florida that was developed by staff from the District and Florida Atlantic University (FAU). This model, the Lower East Coast subRegional (LECsR) model, is a high resolution groundwater flow model of the surficial aquifer system (SAS) covering approximately 7500 square miles. It is related to a regional model (the South Florida Water Management Model, or SFWMM) and several county-wide subregional models. The LECsR model is intended to simulate the groundwater flow of the SAS, wetland hydroperiods, water deliveries, canal/aquifer interaction, and general management of the water resources for the Lower East Coast of Florida. The model will be used as an interpretive and predictive tool to answer a wide range of questions. The model will be used to support: 1) water supply plans, 2) minimum flows and levels (MFLs), 3) core District projects for evaluating engineering designs, permitting and operational rules, 4) water reservations, 5) components of the Comprehensive Everglades Restoration Program (CERP), and 6) Acceler8.

The purpose of the peer review is to evaluate model objectives, conceptualization, design, assumptions, and documentation as well as the model's suitability for its intended applications. The peer review is intended to ensure that the LECsR model was developed and implemented based on sound science and modeling principles.

Peer Review Process

The peer review was conducted by a panel consisting of two university professors and a groundwater consulting engineer. The peer-review panel (Panel) conducted an initial review of the model based on the draft model documentation prior to participating in an introductory meeting with the LECsR Modeling Team at District headquarters on March 13, 2006. They then prepared over 300 questions and comments based on a more detailed review. The Modeling Team's response to the questions and comments were discussed at a workshop held at District Headquarters on April 4. The Panel considered the Modeling Team's response to comments and additional analyses that were performed during the course of the review in preparing the draft Peer Review Report. The draft Peer Review Report was reviewed by the Modeling Team, who provided clarification and/or comment to any outstanding issues for inclusion in this final Peer Review Report. The District and Modeling Team will decide how to consider the Panel's comments and recommendations in developing the final model documentation of the LECsR model. Throughout the peer-review process, weekly teleconferences of one to two hour duration were held with the Modeling Team and Panel. The purpose of the calls was to obtain clarification from the Modeling Team on various issues, to keep the Modeling Team and public informed about progress of the review, and to allow the Panel members to interact with one another. Another important communication tool was an internet-based Web Board that allowed the Modeling Team and the Panel to post questions, comments, and works in progress. The Web Board provided an interactive means of following the progress of the review or to be an active participant.

The Panel commends the District and Modeling Team for their organizational skills in making the peer-review process work smoothly. In addition, the Modeling Team's extraordinary efforts in providing timely and accurate responses to the Panel's questions and comments were helpful and greatly appreciated by the Panel.

Findings

Findings from the peer review are discussed in categories of the documentation, model development, model application, and strengths and weaknesses of the model.

The Panel reviewed the March 2006 version of the draft Lower East Coast subRegional Model Documentation. This report includes text, tables, figures, and three appendices. The Panel understands that the purpose of the model documentation is to provide a detailed overview of the model, the process by which the model was developed, and results of the calibration, verification and sensitivity analysis. It is also understood that the documentation is not a user's manual and therefore does not present the mechanics of model execution or detailed instructions on data set modification. The Panel finds that the Modeling Team has fulfilled the requirements of commonly accepted standards for model documentation such that the scope of the documentation is appropriate. The Panel finds that the text is generally well organized, the format of the document is appropriate, and that the clarity of the model documentation is high. Finally, the Panel finds that the Team's use of figures and tables is appropriate and serves to clarify and enhance the document. The Panel made editorial suggestions and comments that are included in this peer review report.

With regard to model development, the Panel believes that the Modeling Team followed accepted practice in developing and describing the conceptualization of the model and that they incorporated all major (and many minor) components of the surface and shallow aquifer water resources system in the model. The Panel finds that the model construction (boundary conditions, discretization, layering, parameterization) are reasonable and appropriate for the model's intended application.

In the final model documentation, the Modeling Team will update the discussion of the various changes to simulation modules resulting from this peer review and clarify discussion of topics that the Panel believes need greater attention. The Panel believes that the Modeling Team made every reasonable effort to address the concerns raised by the Panel regarding the theory and function of various model modules during the course of the peer review. Some Panel suggestions are for future versions of the model and have been taken under advisement by the Modeling Team. The LECsR model simulates, in satisfactory detail, all of the significant hydrologic and hydraulic watershed functions present within the model domain.

Calibration is the process of refining a groundwater model representation of the hydrogeologic framework, hydrogeologic and hydraulic properties, and boundary conditions to achieve a desired degree of correspondence between the model simulations and observations of the groundwater flow system. An accurate and comprehensive calibration provides confidence that the model will provide accurate predictions of future behavior or response to hydrologic stresses. The Panel finds that the Modeling Team followed standard modeling protocols in calibrating the model. The Modeling Team has performed a comprehensive calibration to many (195) groundwater and surface water level targets that were measured on a daily basis for a 14-year period. Although the Panel found this calibration effort impressive, there was general consensus that additional targets and methods would provide enhanced confidence in the model for specific applications of the model.

The Panel believes that the strengths of the model include: 1) a well-developed and understood conceptual model that is based on a comprehensive data base and knowledge from prior model applications, 2) detailed physical and temporal representation of stresses on the hydrologic system, 3) a good calibration to 195 groundwater and surface water levels that were measured on a daily basis for the 14 year calibration period, and 4) ability to rapidly modify code and develop data to improve predictive capability.

All groundwater models have weaknesses and legitimate use limitations. The LECsR model is no exception. The accuracy to which the LECsR model can simulate the response of the groundwater system to some types of future hydraulic and/or water management structure changes is unknown. The model calibration and verification do not address all possible future changes that may occur within the model domain as these would be virtually impossible to anticipate. However, to the extent practical, the calibration does include consideration of the response of the groundwater system to shifts in wellfield demand and flow into and out of existing impoundments.

Other weaknesses are: 1) there appears to be difficulty confirming some surface water – aquifer seepage rates, 2) there is some spatial bias in the initial calibration due to the non-uniform spatial distribution of the formal calibration targets (i.e. heads at the original 195 wells and surface water gages), and 3) inaccurate ground surface elevations at some initial and new head observation locations cause uncertainty in assumed model parameters and in hydroperiod prediction. The Modeling Team is addressing these three issues by considering additional hard and soft targets and other anecdotal information in an expanded model verification. These additional hard and soft calibration targets will be incorporated directly in model recalibration to be presented in the final model documentation.

Finally, it would improve model validity if the temporal and spatial resolution of well pumping data better matched the finer temporal and spatial scale of the LECsR model. Raw pumping data are typically reported monthly and aggregated as total well field withdrawal. With daily pumping rates unavailable, the Modeling Team uniformly distributes the reported monthly data to estimate daily pumping rates and, therefore, may not match actual daily pumping. The Modeling Team will address this issue to the extent practical and focus on key water supply utilities in the model recalibration to be presented in the final model documentation.

At the request of the Panel, the Modeling Team expanded upon the limitations of the LECsR model that were presented in the draft model documentation. The Panel concurs with the limitations that were identified by the Modeling Team: 1) the LECsR Model does not perform hydraulic routing, and therefore cannot size a canal or estimate overbank flooding, 2) the LECsR Model does not address local-scale issues, such as relocating an individual well or sizing a wellfield, 3) the LECsR Model does not address seepage through a levee, but can address flow under a levee, 4) the LECsR Model does not address event-based hydrological issues, such as predicting peak discharges, and 5) if significant stress is proposed near the western model boundary along WCA-3A, western boundary effects may result from a shift in the water table and it is recommended that the boundary conditions (at that location) are re-evaluated or the model domain is extended.

Recommendations

The Panel made many recommendations to the Modeling Team during the course of the review. The Modeling Team has been responsive to some of these recommendations within the schedule of the peer-review process by conducting requested analyses or by considering inclusion of various additions to the final model documentation. The key recommendations are:

1) Utilize a more sophisticated spatial interpolation methodology than the Inverse Distance Weighting method used for hydraulic conductivity.

2) Adopt the new potential evapotranspiration standard of grass (as opposed to wet marsh crop) when appropriate.

3) Broaden the scope of the calibration to include: a) calibration to the larger set of targets (than the 195 daily targets presented in the draft model documentation) discussed during the peer-review process to cover areas that have limited spatial coverage, b) the recent work performed in demonstrating that the model reasonably matches canal/aquifer seepage rates and/or flow to tide, c) calibration to “soft” targets, including the recent work by the Modeling Team to verify the match to wetland hydroperiods, and d) evaluate and present the calibration metrics for specific periods in time in addition to the metrics presented for the entire calibration period.

4) Provide a more comprehensive description of the calibration process than is included in the current documentation. This description should systematically and perhaps chronologically elucidate the logical decisions and reliance on prior information from the county-wide models. *Anderson* (1983) suggests that the thought process needed when applying [and developing] a model should lead to decisions, not necessarily the model answers. It would be useful, to the degree possible, to document the thought process that went into the LECsR model.

5) Consider expanding the verification period to a length greater than the currently used 14 month period. The panel expressed some concerns that this verification period may not be substantially different in terms of hydrologic stress and/or system operational changes from the calibration period. Consequently, the verification period may not be "challenging" enough to determine how robust the model is in accurately responding to extreme stresses on the system.

6) Strive towards verifying that the model can accurately predict the effect of specific projects (as outlined in the model objectives) or hydrologic responses (wetland hydroperiods, canal seepage changes) by isolating and evaluating subsets of the existing calibration targets based on location and time of an imposed stress on the system. With regard to wetland hydroperiods, additional information, particularly more detailed topographical data, may be required for hydroperiod prediction.

7) In lieu of the previous recommendation, which may not be possible because significant changes to the system have not yet occurred, conduct post-audits of the ability of the model to predict these changes. The post-audits will either provide additional confidence in the model or suggest ways in which the model should be modified. These post-audits should be a part of an ongoing model maintenance task that will provide continuous improvement of the model's predictive capability.

8) To conduct a comprehensive technical edit of final document.

9) Add additional clarifying text and figures as discussed in the body of the peer review document and list of questions.

The Modeling Team should be commended for an impressive accomplishment in developing this comprehensive model of the Lower East Coast groundwater system. The model is a very complex tool that addresses a wide range of processes in the South Florida area. The Modeling Team has developed a tremendous amount of experience that is apparent in the document and in dialogue with the members of the Modeling Team.

District Response to Panel Recommendations

The Modeling Team's responses to the Panel Recommendations are as follows:

1) *"Utilize a more sophisticated spatial interpolation methodology than the Inverse Distance Weighting method used for hydraulic conductivity."* The Modeling Team agrees that a more sophisticated interpolation technique could be employed to better represent the curvilinear nature of the depositional environments of the aquifer system. The more sophisticated methodology will be considered in future revisions to the model and implemented, assuming the more sophisticated technique results in an improved model calibration.

2) *"Adopt the new potential evapotranspiration standard of grass (as opposed to wet marsh crop) when appropriate."* The Modeling Team concurs that grass should

be used as the reference crop instead of wet marsh. The use of wet marsh is a District Policy decision to be consistent with other District models, and the Panel's recommendation will be presented to District Managers for guidance.

3) *"Broaden the scope of the calibration to include: a) calibration to the larger set of targets (than the 195 daily targets presented in the draft model documentation) discussed during the peer-review process to cover areas that had limited spatial coverage, b) the recent work performed in demonstrating that the model reasonably matches canal/aquifer seepage rates and/or flow to tide, c) calibration to "soft" targets including the recent work by the Modeling Team to verify the match to wetland hydroperiods, and d) evaluate and present the calibration metrics for specific periods in time in addition to the metrics presented for the entire calibration period."* The Modeling Team has begun this process (a-d) and has presented a number of results to the Panel during the review process. The number of wells has been increased to approximately 250 wells to address the spatial coverage issue. Calibration to canal flows has begun in those areas that were not specified in the report. North Palm Beach canal flows were included in the draft document. Calibration results of flows in Broward and Miami-Dade Counties will be included in the final LECsR Documentation. Soft target calibration has begun in southern Miami-Dade County, Palm Beach County, including the Everglades Agricultural Area, and Martin County. Soft calibration for wetland hydroperiods will be under investigation following a more thorough evaluation of topography at representative surface water gages. In the interim, the Modeling Team will continue to evaluate relative changes in hydroperiods between the historical and simulated data. The Modeling Team will present the results of our findings in the final LECsR Documentation. The Modeling Team has developed the calibration statistics for the global model in which the Team will create subsets of the statistics in smaller space and time increments as suggested in the Panel's third and sixth recommendations.

4) *"Provide a more comprehensive description of the calibration process than is included in the current documentation. This description should systematically and perhaps chronologically elucidate the logic decisions and reliance on prior information from the county-wide models. Anderson (1983) suggests that the thought process needed when applying [and developing] a model should lead to decisions, not necessarily the model answers. It would be useful, to the degree possible, to document the thought process that went into the LECsR model."* The Modeling Team agrees that a more comprehensive description of the calibration process will be included in the final document.

5) *"Consider expanding the verification period to a length greater than the currently used 14 month period. The panel expressed some concerns that this verification period may not be substantially different in terms of hydrologic stress and/or system operational changes from the calibration period. Consequently, the verification period may not be "challenging" enough to determine how robust the model is in accurately responding to extreme stresses on the system."* Future

versions of the model will include an extended verification period. It is anticipated that the verification period will increase from 14 months to five years. This effort is largely dependent on the extension of the climatic variables (mainly reference ET) beyond year 2000 and is also dependent on District modeling policy. The Panel's recommendation will be presented to District Managers for guidance.

6) *"Strive towards verifying that the model can accurately predict the effect of specific projects (as outlined in the model objectives) or hydrologic responses (wetland hydroperiods, canal seepage changes) by isolating and evaluating subsets of the existing calibration targets based on location and time of an imposed stress on the system. With regard to wetland hydroperiods, additional information, particularly more detailed topographical data, may be required for hydroperiod prediction."* The Lower East Coast subRegional Model is designed to be a subregional tool and does not address local-scale issues. As projects are requested, a detailed analysis of the model will be conducted to address sub-basin level issues at each project site. In addition, the Modeling Team will continue to strive towards verifying that the model can predict the effects of specific projects as they come online. Evaluation of wetland hydroperiods will be under investigation following a more thorough assessment of topography at representative surface water gages. In the interim, the Modeling Team will continue to evaluate relative changes in hydroperiods between the historical and simulated data. The Modeling Team will present the hydroperiod results of our findings in the final LECsR Documentation.

7) *"In lieu of the previous recommendation, which may not be possible because significant changes to the system have not yet occurred, conduct post-audits of the ability of the model to predict these changes. The post-audits will either provide additional confidence in the model or suggest ways in which the model should be modified. These post-audits should be a part of an ongoing model maintenance task that will provide continuous improvement of the model's predictive capability."* Standard modeling protocol recommends post-auditing of models (Anderson and Woessner, 1992). The Modeling Team concurs with the Panel's recommendation of post-audits.

8) *"To conduct a comprehensive technical edit of final document."* The Modeling Team will conduct a more thorough editing of the document including all additions made to the document.

9) *"Add additional clarifying text and figures as discussed in the body of the peer review document and list of questions."* Clarifying text has and will continue to be added to the document as discussed during the peer review process. Select figures that are consistent with standard model documentation will also be added.

Throughout the peer review process, the Panel promoted open discussion relating to a wide range of relevant topics and was open to receiving materials from the Modeling

Team that assisted in understanding the model. The Panel's extensive academic and practical experience facilitated the review process by encouraging the Modeling Team to broaden the utility of the model, to build strengths where strengths exist, and to improve upon weaknesses by making several insightful recommendations.

CHAPTER 1
Introduction

The South Florida Water Management District (District) commissioned a peer review of a groundwater flow model of the Lower East Coast that was developed by staff from the District and Florida Atlantic University (FAU), collectively referred to as the Modeling Team. This report is the ultimate product of the peer review process and presents the findings of the peer review panel (Panel). The Panel members are:

- Peter F. Andersen, P.E., (Chairman) a vice president and principal engineer at GeoTrans Inc., an environmental consulting company located in Roswell, Georgia,

- John M. Shafer, CPH, Ph.D., director and research professor with the Earth Sciences and Resources Institute at the University of South Carolina, Columbia, South Carolina,

- Richard C. Peralta, P.E., Ph.D., a professor with the Biological and Irrigation Engineering Department at Utah State University, Logan, Utah.

The Modeling Team consists of:

- Jeff Giddings, Section Manager, Water Supply, Resource Evaluation and Subregional Modeling Division,

- Kevin Rodberg, Section Manager, Water Supply, Resource Evaluation and Subregional Modeling Division,

- Jorge Restrepo, Ph.D., Director and Research Professor, Center for Hydrology and Water Resources at Florida Atlantic University,

- Laura Kuebler, Staff Hydrogeologist, Water Supply, Resource Evaluation and Subregional Modeling Division,

- Angela Montoya, Senior Hydrogeologist, Water Supply, Resource Evaluation and Subregional Modeling Division,

- Hope Radin, Staff Hydrogeologist, Water Supply, Resource Evaluation and Subregional Modeling Division.

The report is organized as follows. The introduction presents a summary of the model and objectives, the scope of the peer review, and a description of the peer review process. The next chapter provides a review of the model conceptualization and design, including the basis for the model and construction. A review of the calibration of the model, verification, and sensitivity analysis follows as Chapter 3. The model documentation, including organization, clarity, illustrations and tables, is reviewed in Chapter 4. The Panel's collective answers to 21 topic questions posed by the Modeling Team are then presented in Chapter 5. Finally, the Panel's overall findings and recommendations are summarized in Chapter 6. Appendices containing the scope of work, the Panel's questions to the Modeling Team, the Modeling Team's response to the questions, the answers from individual panel members to the 21 topic questions posed by the Modeling Team, and minutes from meetings are also included.

Summary of LECsR Model and Objectives

The Lower East Coast subRegional (LECsR) model is a high resolution (704 ft uniform grid spacing) groundwater flow model of the surficial aquifer system (SAS) covering approximately 7500 square miles. It is related to a lower resolution (10,560 ft uniform grid spacing) regional model (the South Florida Water Management Model, or SFWMM), from which it may obtain boundary conditions for predictive simulations, and several county-wide subregional models from which an understanding of system response has been obtained. The LECsR model was developed using MODFLOW-96 (*Harbaugh and McDonald,* 1996), a modular three-dimensional finite difference groundwater flow modeling framework developed by the United States Geological Survey.

The LECsR model is calibrated to 195 wells and surface water gages having daily water level measurements for the period 1986 to 1999. The LECsR model is intended to simulate the groundwater flow of the SAS, wetland hydroperiods, water deliveries, canal/aquifer interaction, and general management of the water resources for the Lower East Coast of Florida. The model will be used as an interpretive and predictive tool to answer a wide range of questions. The model will be used to support the following District projects: 1) water supply plans, 2) minimum flows and levels (MFLs), 3) core District projects for evaluating engineering designs, permitting and operational rules, 4) water reservations, 5) components of the Comprehensive Everglades Restoration Program (CERP), and 6) Acceler8 (*Giddings, et al.*, 2006).

Peer Review Scope

The purpose of the peer review is to evaluate the following:

- Model objectives, conceptualization, design, and assumptions made for input model data sets,
- Model documentation (explanation of model, data sources, and assumptions),
- Suitability of model for its intended applications.

The intent is to ensure that the LECsR model was developed and implemented based on sound science and modeling principles.

The scope of work includes:

- Conducting a preliminary review of the model based on the draft model documentation (*Giddings, et al.*, 2006),
- Reviewing and evaluating the model documentation,
- Submitting questions and comments to the Modeling Team,
- Reviewing and evaluating the suitability of the model for its intended application,
- Actively participating in workshops and teleconferences,
- Responding to topic questions,
- Preparation of the draft Peer Review Report,
- Preparation of the final Peer Review Report.

It should be noted that the model documentation and supporting written material were reviewed. The Panel did not review model data sets or run the model. The Panel believes that its review is comprehensive despite not directly reviewing the data sets because the complexity of the model renders direct data set review inefficient and because much of the model input and output were transferred directly to report figures that were reviewed.

Description of Peer Review Process

The peer review process was initiated with the transfer of the model documentation to the Panel on March 9, 2006. The Panel had the opportunity to read the document prior to a one-day orientation meeting held at the District headquarters on March 13. The meeting included introduction of project staff, instructions on the ground rules for the review (Florida Sunshine Laws, use of a Web Board, etc.) and a presentation on the model. The Panel asked several questions that were answered by the Modeling Team. The Panel was given a helicopter tour of representative features of the study area. Minutes from this meeting are included in Appendix A. Following the visit, the Panel developed a list of 321 questions about the model and submitted it to the Modeling Team on March 27.

Another meeting was held at District headquarters on April 4 during which the Modeling Team provided answers to the Panel's questions that required discussion. The meeting was conducted in a workshop format where significant interaction between the Panel and Modeling Team took place. A complete response to all the questions was submitted to the Panel members on April 7. A complete list of the questions and answers is provided in Appendix B. At this time the Panel began working on the draft Peer Review Report. This report is a joint effort among panelists, however, the initial writing assignments were:

- Peter F. Andersen: Executive Summary, Introduction, Model Documentation, Overall Findings and Recommendations

- John M. Shafer: Model Conceptualization and Design, Calibration Target Selection, and Model Verification
- Richard Peralta: Calibration and Sensitivity Analysis

Interim sections of this report were placed on an Internet-based Web Board for review by other Panel members, who provided comments and suggested revisions to sections other than the ones for which they were primary author. The draft report submitted to the Modeling Team was compiled and edited by the chairman of the Panel following the comments and revisions by other Panel members.

Throughout the process, weekly teleconferences of one to two hour duration were held with the Modeling Team and Panel. The purpose of the calls was to obtain clarification from the Modeling Team on various issues, to keep the Modeling Team and public informed about progress of the review, and to allow the Panel members to interact with one another.

Another important communication tool was an Internet-based Web Board that allowed the Modeling Team and the Panel to post questions, comments, and works in progress. The Web Board provided an interactive means of following the progress of the review or to be an active participant.

CHAPTER 2
Model Conceptualization and Design

LEC Groundwater Conceptual Model

A conceptual groundwater flow model is an idealization of the real world that summarizes the current understanding of the behavior of the groundwater system being modeled (*Spitz and Moreno*, 1996). It should embody all the important features of the flow system and identify all simplifying assumptions associated with this understanding. According to *Anderson and Woessner* (1992) a conceptual groundwater flow model is often a pictorial representation of the groundwater flow system, often in the form of a block diagram or cross-section. *Mercer and Faust* (1981) state that the conceptual model should include consideration of cause and effect relationships that drive how the system being modeled behaves. Conceptual groundwater models are developed by following a three step process wherein (1) the hydrostratigraphic units of importance are determined; (2) a water budget is prepared; and (3) the flow system, including groundwater – surface water interaction is defined (*Anderson and Woessner*, 1992).

Giddings, et al. (2006) devote a significant portion of the model documentation to discussing the LECsR model conceptualization. The Panel notes that considerable understanding of groundwater system behavior within the LECsR model domain has been achieved through previous District subregional county-specific groundwater model development. Therefore, much knowledge of groundwater and surface water behavior in the LECsR model domain was known prior to development of the LECsR model. Nevertheless, the Panel evaluated the adequacy of conceptual LECsR model development against the three fundamental steps in conceptual model development outlined above as described by *Giddings, et al.* (2006).

Definition of Hydrostratigraphic Units

The first step in creating the conceptual model of a groundwater flow system is to define the area of interest (*Anderson and Woessner*, 1992). This equates to identifying the physical boundaries of the model, both geographically and vertically. Whenever possible, and appropriate, natural hydrologic boundaries should be used as the model domain boundaries.

Giddings, et al. (2006) describe, in detail, the geopolitical and natural boundaries of the LECsR model. They identify the major cultural areas within the model domain including urbanized environments, Everglades Agricultural Area, stormwater treatment areas, water conservation areas, and Everglades National Park. Natural surface or groundwater conditions are used to define all model domain boundaries. The eastern model boundary is the tidally influenced Intracoastal Waterway; the St Lucie Canal (C-44) is the northern model boundary; Lake Okeechobee bounds the northwest corner of the model; water management district canals represent the western model boundary; the southwest boundary is the groundwater divide in Everglades National Park; and the southern boundary of the model is Florida Bay.

The top physical boundary of the model domain is land surface. Given the minimal topographic relief throughout the model domain and the significance of overland flow, control on land surface elevation is an important aspect of model development. The Modeling Team incorporated elevation data from a wide variety of sources, including LIDAR, U.S. Geological Survey high accuracy elevation data, and digital elevation models from small areas throughout the model domain (please refer to Chapter 2 of the model documentation for more details). However, there is inherent accuracy variability among the various sources of topographic data. This suggests that throughout the model domain the simulated hydrologic processes that are a function of land surface elevation (or relief) will be more or less accurate depending on the accuracy of the land surface elevation.

The vertical model extent includes all the recent, Quaternary, and Tertiary stratigraphic units lying above the Hawthorn Group, which is a low permeability thick sequence of clays and marls occurring continuously throughout the model domain. The Hawthorn Group is the bottom no-flow boundary of the model. The package of geologic units above the Hawthorn Group is referred to as the Surficial Aquifer System (SAS) and is the body of the LECsR model. *Giddings, et al.* (2006) provide detailed lithostratigraphic descriptions of all geologic deposits included in the model domain and the rationale for combining units to form the three hydrostratigraphic units incorporated into the model geometry. Further, the units composing the Biscayne Aquifer, as a member of the SAS, are described. The Panel agrees that the Modeling Team has performed a very thorough investigation of the stratigraphy and hydrostratigraphy within the model domain. *Giddings, et al.* (2006) present geologic cross-sections based on "stick" logs showing the stratigraphy of the various borings along each transect. The Panel believes that the Modeling Team provides adequate justification for establishing the LECsR model domain three-unit layering. The Panel recommends that, in addition to the figures in the documentation that describe the lithostratigraphic units of the SAS, a west-east and a north-south continuous lithostratigraphic cross-section (as opposed to the stick log cross-sections) showing the various geologic units, their thicknesses, and orientation within the SAS be included in the documentation.

Water Budget Preparation

Rainfall represents the largest input of water into the LECsR model domain and has a strong effect on surface and groundwater behavior. The Modeling Team incorporated the daily precipitation records from 26 rainfall stations located throughout the model area in formulating model input. A Thiessen polygon approach is used to spatially distribute rainfall within the model domain.

Giddings, et al. (2006) provide significant detail on water use throughout the model domain including consideration of saltwater intrusion into the Biscayne Aquifer. Land use and associated distribution of water use by major category (e.g., agriculture, public water supply, etc.) are presented along with permitted water use in million gallons per day (MGD) per south Florida counties. The distribution of public water supply wells is discussed, as is the spatial pattern of consumptive use by water use class other then public water supply.

Due to the size, complexity, and spatial/temporal variation of the LECsR model domain, it probably is not feasible to develop *a priori* a detailed quantitative water budget (inputs versus outputs). However, the Modeling Team does account for all known inputs (primarily precipitation) and outputs (e.g., ET, flows to tide, well discharges, boundary gains/losses, etc.) in the model formulation. A post-calibration assessment of model performance can be used to judge how well the model conceptualization captured the relevant water budget components.

Definition of Flow System

The LECsR model is extremely complex. There are a large number and wide variety of natural and manmade groundwater and surface water storage, conveyance, and withdrawal features located throughout the model domain. The primary focus of the LECsR model is the natural groundwater system and production wells and wellfields are included in the model formulation. However, the Surficial Aquifer System is highly integrated and interactive with surface water systems. Therefore, to accurately model groundwater behavior in the model area, groundwater – surface water interactions must be incorporated into the model formulation. The Modeling Team included the complex primary, secondary and tertiary canal network in the LECsR model formulation. Lake Okeechobee is included as a boundary condition. Wetland ecosystems such as the managed Everglades Protection Area and water conservation areas are incorporated into the model as are a number of naturally occurring sloughs and drainageways. *Giddings, et al.* (2006) specifically discuss the myriad nuances of the regional flow system operation and how it influenced model formulation.

The Panel believes that the Modeling Team followed accepted practice in developing and describing the conceptualization of the LECsR model. Further, the Panel agrees that the Modeling Team has an in-depth, and perhaps unique, understanding of the complexities of the groundwater and surface water systems of the LEC. Based on this knowledge, the Modeling Team incorporated all major (and many minor) components of the surface and shallow aquifer water resources system in the LECsR model.

Representation of the Hydrologic System

Simulation Modules

The LECsR model is an integration of standard MODFLOW-96 modules with several specialty modules developed by (or for) the District to address the peculiarities of the LEC groundwater – surface water system. The standard MODFLOW-96 modules implemented in the LECsR model are all validated and well-documented. These include the BAS, BCF, OC, RCH, EVT, RIV, DRN, HFB, GHB, WEL, and SIP modules. The Panel questioned why the Modeling Team is using MODFLOW-96 versus MODFLOW-2000 for the LECsR model as MODFLOW-2000 is an updated version of the U.S. Geological Survey groundwater modeling software. The Modeling Team uses MODFLOW-96 due to the necessity for compatibility between the software coding of the custom modules and the FORTRAN coding of MODFLOW-96. The Panel accepts this rationale for not implementing MODFLOW-2000.

The implementation of the standard MODFLOW modules in the LECsR model conforms to the normal application of these routines. The Panel encourages the Modeling Team to adopt the new estimates of potential and reference evapotranspiration (ET) based on grass in future versions of the LECsR model. However, the Panel agrees that the current model ET reference of wet marsh crop is acceptable.

The Modeling Team is well-familiar with the standard MODFLOW modules and has appropriately implemented these modules within the model domain. The Panel focused attention on the custom modules that have been developed by, or for, the District to address surface water – groundwater phenomena that cannot be adequately simulated with the standard MODFLOW modules (*Giddings, et al.*, 2006). These modules are the Diversion (DIV), Reinjection Drainflow (RDF), Wetland (WTL), and TRG (Trigger – not used for model calibration) packages. In addition to these custom process modules, two additional modules were developed to manage input and output, namely UGEN (Utility Generation), and BUD (Multibud).

The DIV module simulates the effects of both pumping stations and gravity flow drains on water levels. The RDF module is similar to the standard drain package except the RDF module allows water to be redirected to another location in the model domain versus being permanently removed from the model. The WTL module is implemented in model layer one to simulate overland flow in wetland areas. The WTL module is very important to overall model performance because it is applied to much of the LECsR model layer one domain and controls groundwater – surface water interaction over large areas of the model. The TRG module, used only for predictive simulations, simulates wellfield withdrawal cutbacks based on water levels in "trigger" cells and in Lake Okeechobee and simulates LEC water shortage policy associated with saltwater intrusion.

The Panel carefully reviewed each of the add-on District packages considering their technical validity and their implementation in the LECsR model. Overall, the Panel finds the add-on packages to be expertly designed, well-tested, and correctly implemented within the model framework. The Panel made several suggestions, noted in the formal questions and answers and in the minutes of the public meetings, for minor improvements in the implementation of certain packages and/or their discussion in the model documentation. The Modeling Team implemented several Panel recommendations during the course of this peer review. For example, the UGEN package now provides for the stage in a canal (River Module) to equal the bottom of the canal during a dry month thereby causing no unintended affect on water table elevations. However, during wet months, the canal operates normally as a MODFLOW "river".

The Panel explored many aspects of the theoretical underpinnings of the WTL module and its implementation in the LECsR model. The formulation of the wetlands package was presented in a peer-reviewed article by *Restrepo, et al.* (1998) and it appears to be well-vetted. The Panel agrees that the WTL module is capable of satisfactorily simulating overland flow as required within the framework of the LECsR model. For the grid resolution in the LECsR model, the module appears to be most suitable for wetlands of regional to sub-regional scale (>100 acres) such as those within the model domain. As the WTL package was originally implemented in the model, values for the Kadlec exponents α and β were not allowed to vary spatially. This restriction tends to limit the effectiveness of the WTL package in specific areas of the model domain. For example, in Shark River Slough an artificially high soil hydraulic conductivity is required to simulate the rate of overland flow observed because the Kadlec computed overland flow in this area is limited by the values of α and β. During the peer review process, the Modeling Team modified the WTL package to allow the Kadlec β coefficient to vary spatially and re-ran the model calibration.

In the final model documentation, the Modeling Team will update the discussion of the various changes to simulation modules resulting from this peer review and clarify discussion of topics that the Panel believes need greater attention. The Panel agrees that the Modeling Team made every reasonable effort to address the concerns raised by the Panel regarding the theory and function of various model modules during the course of the peer review. Some Panel suggestions are for future versions of the model and have been taken under advisement by the Modeling Team. The LECsR model simulates, in satisfactory detail, all of the significant hydrologic and hydraulic watershed functions present within the model domain.

Boundary Conditions

A model boundary is the interface between the model calculation domain and the surrounding environment (*Spitz and Moreno*, 1996). Typical groundwater model hydrologic boundaries are surface water bodies (e.g., Lake Okeechobee, Intracoastal Waterway, and canals), impermeable boundaries (e.g., the Hawthorn Group – bottom boundary of the LECsR model), the water table, and local sources and sinks. Groundwater flow models are customarily designed to take advantage of natural and manmade flow boundaries (versus artificial boundaries) to the extent possible. No artificial or fictitious boundaries are employed in the LECsR model. The Modeling Team followed standard groundwater modeling practice in establishing the outer boundaries of the LECsR model using the MODFLOW GHB (general head boundary) module. Surface water features surrounding the model domain (e.g., Lake Okeechobee, Intracoastal Waterway, and canals) are the physical boundaries of the model. The north to south trend in tide elevations is accounted for in the model formulation. Further, a density correction is made to the eastern tidally, influenced model boundary to compensate for salinity effects on hydraulic head. The Panel finds the LECsR model boundary conditions to be reasonable and appropriate for the model domain.

Spatial and Temporal Discretization

The LECsR model is composed of three layers with each layer divided into 1033 rows and 408 columns of uniform 704 ft by 704 ft cells. The Panel initially questioned the logic behind selecting 704 ft by 704 ft as the grid cell size. The rationale for this grid size is the need to interface the LECsR model with the SFWMM 2 mi by 2 mi grid. There are 225 LECsR model cells per SFWMM cell. Each cell in the LECsR model is approximately 11 acres in area. Given the overall size of the model domain, the 704 ft by 704 ft cell dimensions appear to provide ample grid density to provide the required resolution in model output for the types of issues to be addressed by the LECsR model.

The temporal resolution of the LECsR model is one day. Each model stress period is set to the one-day time step. While many data inputs (e.g., precipitation) are available in daily increments, others such as well pumping and some surface water gage data are available only on weekly or monthly intervals. These data sets are typically uniformly distributed over their recording frequency to estimate daily values. For model calibration, the hard targets for water level calibration are a series of well hydrographs with daily time increments and surface water gages that also have daily measurements. The Panel finds both the spatial and temporal LECsR model discretization to be reasonable and appropriate for the intended purposes of the model.

Model Layering

The Modeling Team gave careful consideration to the development of the vertical model structure. The stratigraphy and lithology of the upper geologic units present within the model domain were evaluated with regard to hydrostratigraphic properties and depositional environments. The Hawthorn Group is a regionally continuous, low permeability formation that acts as a natural boundary between the Surficial Aquifer System and the deeper groundwater resources in southern Florida. Therefore, it is logical that it be the bottom boundary of the model. The various geologic units above the Hawthorn Group were combined to form three model layers that individually represent (starting at land surface) the Biscayne Aquifer, a semi-confining intermediate unit, and the less prolific (than the Biscayne Aquifer) Gray Limestone aquifer. The major surface water - groundwater interaction is between surface water management structures and the Biscayne Aquifer. This important relationship is preserved in the model layering. The Panel finds the LECsR model layering to be suitable for the proposed uses of the model and that the geological environment the model emulates is adequately represented in the model structure. The Panel encourages the Modeling Team to include in future revisions to the documentation at least two (west-east and north-south) model grid cross-sections in addition to the horizontal model mesh figure shown in the current version of the documentation.

Model Input Data Sets

Hydrogeologic Parameters

The principal hydrogeologic parameters of a transient groundwater flow model are hydraulic conductivity and storativity. The Modeling Team combined three different sets of data related to hydraulic conductivity to develop the hydraulic conductivity fields input to the LECsR model. The three types of data are specific capacity test analyses, hydraulic conductivity estimates from geologic control well cores, and aquifer performance test (APT) analyses. At the spatial scale of the LECsR model, data from the above sources represent point-wise estimates of hydraulic conductivity with a non-uniform spatial distribution over the model domain. The majority of aquifer tests within the modeled area were conducted in the northeastern part of the model while specific capacity tests where conducted from the east-central portion of the modeled area southward. Hydraulic conductivity estimates from core analyses are scattered throughout the model domain.

There is some dispute among groundwater scientists over the comparability of hydraulic conductivity estimates from different estimation approaches. For example, the hydraulic conductivity derived from a multi-well aquifer test has different statistical support than an estimate from analysis of a core sample. Nevertheless, given the wide range of hydraulic conductivities throughout the model domain and the need to provide as large a spatial coverage as possible, it is reasonable for the Modeling Team to consider hydraulic conductivity data from all sources for purposes of populating the model.

Using the hydraulic conductivity database, the Modeling Team first estimated the spatial distribution of horizontal hydraulic conductivity for each geologic unit in the model domain using an inverse distance weighting (IDW) methodology. While (IDW) is an accepted interpolation scheme, it has certain limitations that are evidenced in the plots of horizontal hydraulic conductivity in the documentation (*Giddings, et al.*, 2006). The hydraulic conductivity "bull's eyes" seen in the figures are more likely artifacts of the interpolation scheme, than representative of hydrogeologic conditions. However, this phenomenon is somewhat smoothed in the process of averaging the geologic unit hydraulic conductivities (via transmissivity) to obtain each model layer hydraulic conductivity field, and does not appear to have any appreciable negative impact on model calibration. Nevertheless, the Modeling Team is encouraged to consider more sophisticated approaches to interpolation of spatial data (than IDW) in future modifications to the modeling process and the model itself.

The Modeling Team's approach to establishing the vertical conductance coefficient is that recommended by the developers of MODFLOW. Due to the extreme horizontal bias (versus vertical) in hydraulic conductivity (anisotropy ratio set to 20:1 horizontal to vertical), and the fact that model layer one (i.e., Biscayne Aquifer) dominates much of the model performance, the model is relatively insensitive to vertical conductance.

Storativity considerations are input to the LECsR model as specific yield for unconfined layer one and as storage coefficients for model layers two and three. In comparison to hydraulic conductivity, the range in storativity, especially specific yield, in granular porous media is fairly limited. The Modeling Team applied a uniform specific yield of 0.20 and evaluated model sensitivity to an increase and decrease of 0.10 from this value. The LECsR model appears to be relatively insensitive to the above perturbation in specific yield. The Panel believes that the selection of 0.20 for specific yield in layer one is an acceptable value and that, due to its relative insensitivity, the application of a uniform specific yield throughout layer one is justified.

The Modeling Team applied a spatially varying storage coefficient to LECsR model layers two and three. The input storage coefficients were calculated by multiplying a uniform specific storage (i.e., 5.0×10^{-6} 1/ft) times the varying layer thickness. The specific storage was determined from the APTs conducted in various locations throughout the model domain. This approach to establishing the storage coefficient throughout the model domain is reasonable and accounts for spatial variability throughout model layers two and three. The Panel asks the Modeling Team to clarify the discussion of storativity in the draft LECsR model documentation (*Giddings, et al.*, 2006).

Surface Water – Groundwater Interaction Parameters

The wetland package requires parameterization over the model areas designated as wetlands. Wetlands within the model domain were identified from 1995 land use data. The wetland flow system divides model layer one into ponded water, muck and peat, and the underlying sediments down to 0.0 ft NGVD. The specific yield for ponded water and muck/peat is set to 0.9 and 0.3, respectively. These values are reasonable estimates for the LECsR model. Implementation of the wetlands package also requires the input of Kadlec conductance coefficients along with α and β. The Kadlec conductance coefficient was assigned to each cell based on the land use or vegetation type representing the most area of the cell. These values were designated during model design and are not based on field data. However, it is apparent that careful attention was given to their selection.

Initially, Kadlec equation exponents α and β were held constant throughout the model domain. However, after discussion with the Panel regarding the inability of the wetlands package alone to adequately simulate the overland flow in Shark River Slough, the Modeling Team modified the LECsR model to allow β to vary spatially, thereby facilitating fine tuning of the wetlands package in certain areas of the model domain. The Panel believes this adjustment improves the applicability of the LECsR model.

As previously discussed, the Panel recommends that the Modeling Team adopt the new potential evapotranspiration standard of grass (as opposed to wet marsh crop) when appropriate.

The Panel finds that the parameterizations required in MODFLOW modules not specifically noted above were done so following standard practice in the application of the MODFLOW groundwater modeling platform.

CHAPTER 3
Calibration and Sensitivity Analysis

Introduction and Overview

The LECsR model is intended to be "capable of simulating the groundwater flow of the Surficial Aquifer System (SAS), wetland hydroperiods, water deliveries, canal-aquifer interaction, and general management of the water resources for the Lower East Coast of Florida" (*Giddings et al.,* 2006). In the previous chapter, the Panel stated that the LECsR model is appropriately designed to simulate hydrologic processes, water deliveries and general water management features. The next step in model development is calibration. Calibration is the process of refining a groundwater model representation of the hydrogeologic framework, hydrogeologic and hydraulic properties, and boundary conditions to achieve a desired degree of correspondence between the model simulations and observations of the groundwater flow system. This chapter reviews the Modeling Team's selection of responses and metrics to achieve calibration, their process of calibrating the model, and the calibration results. The verification of the model and sensitivity analysis is also reviewed.

Early in the review process, the Panel questioned some parameter adjustments made during model calibration. The Modeling Team immediately implemented or began implementing changes that have improved or are improving the LECsR model. The Panel believes that the final documentation of the LECsR model will show a more comprehensive calibration than the draft documentation and will satisfactorily predict heads at the target locations for reasonable climatic and management situations. It will be able to predict values of such head-related performance indicators and the degree to which they achieve performance measures, as described at http://www.sfwmd.gov/org/pld/proj/wpa/wpa/index.html. Included in this review are Panel recommendations to broaden LECsR model utility. The Modeling Team has already undertaken some of these Panel recommendations, and other suggestions listed in Appendix B. Most of those suggestions are not reiterated here.

Calibration Target Selection

A simulation model is intended to accomplish a particular purpose. To achieve that purpose, a simulation model must be calibrated using appropriate calibration targets and methods.

ASTM (2002) defines "calibration targets" as "measured, observed, calculated, or estimated hydraulic heads or groundwater flow rates that a model must reproduce, at least approximately, to be considered calibrated." Calibration criteria are the metrics (e.g., statistical measures of residuals of hydraulic heads, flows, surface water stages, etc.) by which the success of the calibration process is evaluated.

The Modeling Team created an ensemble of "hard" calibration targets consisting of water levels measured in wells and surface water gages. "Hard data" refers to wells and surface water gages where daily values have been recorded, or could be computed, for each of the 5,000 LECsR model stress periods (i.e., days) of the calibration period from January 1986 to September 1999. A transient model calibration was undertaken comparing these observed hydrographs to the groundwater model simulated hydrographs. *Giddings, et al.* (2006) state that "[t]he total number of observation wells used in the calibration is 195 which have continuous recorders on them." However, the Panel understands from the Modeling Team's responses to questions that the reference to 195 "observation wells" is a misnomer and that the 195 calibration targets are composed of "roughly an equal amount of surface water gages and groundwater wells (*Response 184*). As a result of discussion with the Panel, the Modeling Team expanded the 195 calibration targets to almost 250 targets. Three additional hard calibration targets related to monthly structure flows in North Palm Beach were included in the calibration. These are the C-18 West weir, structure G-92, and flows over the Lainhart Dam. The majority of the canals that are incorporated into the model structure function with prescribed (i.e., input) stages, and therefore are not candidate calibration targets.

ASTM (2002a) states that for a medium to high fidelity (i.e., the degree to which a model application is designed to resemble the physical hydrogeologic system) model, such as the LECsR model, calibration targets should be established by compiling and evaluating all relevant available data regarding groundwater levels, flow rates of pumping wells and wellfield discharges, and estimates of groundwater-surface water interactions. Further, consideration should be given to the measurement errors associated with these data. The Panel believes that the Modeling Team followed the guidance set forth in *ASTM* (2002) in establishing an ensemble of hard calibration targets that have consistent and comparable time series data.

There is a non-uniform spatial distribution of the 195 calibration targets within the overall LECsR model domain. Nearly all of the hard target groundwater observation wells are located in the eastern third of the model with a fairly uniform north to south spatial distribution, although the density of wells does increase from north to south. The vast majority of hard target surface water gages are located in Miami-Dade County west of the major target observation well population. The lack of any significant hard calibration targets in the roughly one-half of the northwestern model domain is problematic because there is no way to substantiate that the model accurately simulates groundwater and surface water behavior in large areas where no calibration targets exist. The Modeling Team responded to this concern by providing data for approximately 50 wells that were not included in the formal calibration because they did not meet the stringent quality assurance requirements to be included as hard calibration targets. Further, there are additional surface water gages in the WCAs that were not included in the original data gathering process. Inclusion of these data, to the extent practical, will strengthen the calibration and increase the confidence in model predictions.

Spitz and Moreno (1996) state that model evaluation should use as many pieces of information as possible (not merely water level data), including descriptive data. Descriptive data, or soft calibration targets, such as knowledge of system behavior, flow directions and velocities, general surface water elevation estimates, and other soft information are valid secondary calibration targets. These targets may be from specific areas of the model domain (e.g. canal seepage in a gaged area) and/or specific intervals within the simulation period (e.g. imposition or change in stress on the system). As noted above, in areas where hard calibration targets are not available, soft calibration targets may play a valuable role in demonstrating the accuracy of model simulations in these areas. The Panel has encouraged the Modeling Team to consider adding soft calibration targets to the overall calibration process and to evaluate model performance against both hard and soft calibration targets in future enhancements to the LECsR model. The Modeling Team has responded by including additional water level targets and analyzing wetland hydroperiods.

The Panel believes that the Modeling Team thoroughly evaluated observation well data and surface water gage data in developing a consistent set of transient data for calibrating the LECsR model to predict groundwater and ponded surface water stages near observation locations. The spatial bias noted above is inherent in the non-uniform spatial distribution of the resulting 195 calibration hard targets included in the model documentation. The Modeling Team is addressing this spatial bias with the inclusion of data from approximately 50 additional wells.

The Modeling Team did not directly include in the draft model documentation hydroperiods or surface water flows with heads within its statistical calibration targets. During the peer-review process, the Modeling Team developed a comparison between modeled and observed hydroperiods that appeared to support the model calibration. Further discussion with the Modeling Team suggested that the model is currently capable of predicting relative changes in hydroperiods but not ponding depths. Prediction of actual hydroperiods and ponding depths may be accomplished with inclusion of more accurate topographic data. The Panel encourages the Modeling Team to develop calibration criteria for hydroperiods that are consistent with the limitations of the topographic data.

Calibration Process and Results

To the LECsR model, the Modeling Team brought knowledge on hydrologic system behavior and parameter sensitivity from pre-existing calibrated subregional models (North Palm, South Palm, Broward, North Miami-Dade, South Miami-Dade). Data for those MODFLOW models was derived from much field information, as reported in the separate model reports. The LECsR report summarizes the types of data and knowledge derived from previous models, and additional field information.

A systematic manual groundwater flow model calibration process can include (ASTM, 2002a): (1) selecting observed calibration targets; (2) selecting acceptable maximum values of calibration residuals (possibly differing with variable and region); (3)

identifying calibration parameters; (4) establishing a realistic range of parameter values for parts of or the entire study area; (5) conducting a preliminary calibration sensitivity analysis; (6) matching targets via quantitative and qualitative methods; (7) attempting to resolve significant non-uniqueness issues; and (8) reporting the calibration. A calibration report should discuss the entire process. This includes the rationale concerning parameter changes to improve calibration. It is helpful to incorporate a record or log of calibration runs showing the evolution of parameter values and calibration statistics, and decision-making logic.

The LECsR report addresses most above tasks, but does not detail all tasks to the extent desired by the Panel. Perhaps, the text omissions resulted because the calibration employed knowledge from previous District subregional model calibrations and modeling. Below, the Panel makes recommendations relative to all listed tasks, and encourages the Modeling Team to consider these in their preparation of the final model documentation.

For Task 1, the Modeling Team determined that it would attempt to match daily target heads or stages at 195 continuously monitored locations from January 1986 to September 1999. The 5000-day periods encompasses very wet, average, and very dry hydrologic conditions. This vigorous effort nevertheless under-represents some parts of the study area, as discussed in the previous section on calibration target selection. The Modeling Team has responded to this concern by providing data for approximately 50 additional wells. Also, calibration targets specified in the draft model documentation do not include hydroperiods or surface flow rates, which the Panel believes would increase model usefulness.

Wetland hydroperiods (periods of inundation by surface water) can be predicted by knowing when simulated heads will exist above the ground surface. The Panel recommended that the Modeling Team evaluate hydroperiod matching as a calibration metric. The Modeling Team initially responded by providing data from a particular project site (C-111) that showed that the model generally gave a reasonable match to hydroperiods at that site. The Modeling Team subsequently provided data from other sites that also appeared to support the calibration. However, matching of wetland hydroperiods is considered a soft calibration target at present due to inaccuracies in the topographic data base. Inclusion of new, more accurate topographic data, either in the calibration performed for the final model documentation or on a project-specific basis will provide additional confidence that the model can provide accurate results for projects where hydroperiod determination is important. The Panel suggests that hydroperiod matching should be conducted or documented in the final model documentation.

If possible, the Modeling Team should also attempt to add quantitative surrogates for soft calibration targets. A surrogate can be a range of heads at a particular time, within which a simulated value would be considered acceptable. An example within an EAA cell might be a water level between 1 and 3 feet beneath ground surface. An example in a wetland cell might be a water level between 0.5 and 3 feet above the ground surface in a particular season. An alternative is to have a list of qualitative targets that need to be satisfied by the calibrated model.

Concerning Task 2, selecting acceptable ranges of values or criteria for calibration statistics, the report lists fourteen calibration criteria statistics (seven apply to each individual location, and seven analogous criteria globally present all locations en masse). The Modeling Team's post-processing software summarizes how well a calibration run does in terms of these criteria. The report would be strengthened by including simple explanations of why some of the criteria were selected (for example RES, STD, and +/- 1.0 ft). If still used in the final model documentation, it would be appropriate to explain why the +/- 1.0 ft criterion was used globally, and why it does not vary with locale.

Concerning the topics of Tasks 3-5, Table 2 of the report identifies five main parameters varied in calibration (general head boundary conductance; canal hydraulic conductivity of the sediments; canal sediment thickness; specific yield for the wetlands and underlying muck layer; and hydraulic conductivity of layer one in wetland areas). Chapter subsections discuss varying three of the five parameters, and other parameters (river and drain conductance; root zone extinction depth and ET surface elevations; and urban recharge).

A reader would benefit if the report more clearly described the process of addressing Task 5 goals, including more chronology. It is unclear which model parameters the preliminary sensitivity analysis determined would be allowed to vary during the calibration, and why. The rationale should discuss the impact of knowledge gained from previous work.

Task 6 involves the process and logic of making calibration runs, evaluating results, changing parameter values, and deciding when to cease. It would be helpful if the report clearly stated how calibration criteria statistics guided adjustments of which input parameters. For example, in some situations, the Modeling Team might have decided that the parameters of a particular simulation run were adequately calibrated if three of the four most important criteria were satisfied for all targets (*personal communication, Jeff Giddings*). These four salient criteria are:

- +/- 1.0 Foot = Simulated head lies within +/- 1.0 foot of the measured head at least 75% of the time.
- ME = Mean error (mean difference between measured and simulated heads) is within +/- 1.0 foot.
- MAE = Mean absolute error (mean of the absolute value of the differences between measured and simulated heads) does not exceed 1.0 foot.
- RMSE = Root mean squared error (square root of the average of the squared differences between measured and simulated heads) does not exceed 1.0 foot. (This is defined incorrectly in the draft model documentation.)

The final model documentation should describe which criteria or criteria target values were most difficult to satisfy, and what was necessarily done to achieve satisfaction. The Panel believes that of these four criteria, the + 1.0 foot criterion was the most challenging, and required the most parameter adjustments to achieve (*personal communication, Jeff Giddings*).

The STD criterion allows + the standard deviation of measurements at an observation location, instead of + 1.0 foot. The report should discuss whether and how the STD criterion was or should be used (per Jeff Giddings, it is defined incorrectly in the report).

LECsR model simulation outputs include groundwater and ponded surface water heads and canal-aquifer seepage rates. During calibration and verification, the LECsR model satisfied reasonable accuracy criteria for predicting cell groundwater and ponded surface water heads at target observation locations. The LECsR model also reasonably tracked surface water flows at Lainhart Dam. The Modeling Team is in the process of evaluating the modeled surface flows in other locations.

The report should explain how previous modeling experience affected which parameters the Modeling Team was least likely to change during calibration. For example, if the Modeling Team believed that the wetlands field data-based recharge and evapotranspiration values were relatively sound and better alternatives were not available, the Modeling Team might have used these values almost unchanged in the LECsR model. Similarly, because of the extensive work performed to obtain previously calibrated aquifer hydraulic conductivity values, the Modeling Team might have intended to change these only as a last resort in LECsR model calibration (*personal communication, Jeff Giddings*).

Adding figures to the report would help in explaining the calibration logic. During the model review, the Modeling Team provided figures that significantly aided the Panel's understanding. Similar and improved figures would illustrate how changing calibration parameters near target head locations affect calibration statistics. Such figures would spatially relate the distribution of calibration targets, prediction error, parameter value zonation, wells, canals, structures and other boundary conditions that significantly control predicted heads. The zonation of river or drain conductance near problematic target heads and surface flows should especially be displayed. Example controlling boundary conditions include cells in which surface water stage inputs vary temporally. For such cells, the report should mention how frequently the input surface water stages change. It is especially important that these figures be used to explain efforts to improve calibration near problematic targets.

Presenting the above figures will help support parameter adjustments. For example, the figures will facilitate explaining making changes to river conductance, Kadlec β coefficient, and aquifer layer 1 horizontal hydraulic conductivity.

Because of the proximity of hydraulic stimuli of unknown magnitude and timing, the model cannot be expected to accurately match some target heads (for example, well

G3253). The report should quantify the effect of this uncertainty on predicting nearby observation well heads. Initially the Modeling Team estimated historic groundwater extraction rates from monthly records for public water supplies, and from water use permits for private water supplies. For each water utility, the Modeling Team assumed the proportion of water that was derived from each well within a public well field. To improve predictive accuracy, the Modeling Team has modified the assumed pumping rates as additional data has become available, and intends to continue to do so (*personal communication, Jeff Giddings*).

It would be helpful if the report further summarized interactions between temporal and spatial distributions of predictive error. For different parts of the study area, the report could identify the months, seasons, or climatic conditions (dry, wet, and average) in which the model is most and least accurate. An independent analysis by the Panel indicated that the model tended to give, on average, simulated water levels that were too high during dry seasons when measured water levels were low and simulated water levels that were too low during wet seasons when measured water levels were high. This temporal bias is very small and significantly less than the overall change in water levels between wet and dry seasons but is consistent with the stage-duration curves in Appendix C of the model documentation which indicate that the model generally does not reproduce the extreme high and low water levels. The Panel recommends that the Modeling Team consider this observation in future calibration of the model and also to use calibration targets and criteria that are based on individual points in time or seasons (wet/dry). The calibration metrics in the draft model documentation encompass the entire simulation period and do not address how well the model matches criteria at specific points in time.

The Panel recommends that the Modeling Team establish soft calibration targets or ranges and establish methods of describing success or failure in achieving those targets. Ideally the methods will be somewhat quantitative, even if as simple as counting how many predictions lie within target ranges.

Similarly, the Panel recommends that the Modeling Team enhance the model so it can reasonably simulate or evaluate significant or important surface flows and surface water-aquifer seepage rates. The Modeling Team responded by providing calibration statistics for flows in Lake Worth Drainage District/North Broward Drainage District canals, and other canals. The Panel recommends that these calibration statistics be included in the final model documentation.

The report does not currently address Task 7. However, the Modeling Team clearly realizes the significant potential for non-unique parameter sets, especially in areas of overland flow and surface-groundwater interaction. From among several non-unique parameter data sets, the Modeling Team intends that the model will employ the most realistic. Currently, the Modeling Team is exploring different combinations of Kadlec β coefficient and aquifer layer 1 horizontal hydraulic conductivity to select the best. The final model documentation will explain the logic leading to the selection of a particular parameter set.

To help deal with non-unique parameter sets in urban areas of surface-groundwater interaction, the Panel concurs with a LECsR report recommendation. The Modeling Team recommended that the model code be enhanced so that in urban areas, the depth of the water table affects evapotranspiration losses from the unsaturated zone. In urban cells, evapotranspiration from the unsaturated zone reduces recharge. Enhancing this process modeling would reduce uncertainty in dealing with non-unique parameters sets involving river, canal or drain conductance, recharge, evapotranspiration, and aquifer layer 1 hydraulic conductivity. Note that this recommendation pertains to evapotranspiration from the unsaturated zone and that evapotranspiration from the saturated zone is depth dependent through use of the MODFLOW ET package.

Task 8 involves reporting the calibration. Following the above recommendations will improve Task 8 accomplishment. This includes making changes to data and modeling algorithm(s), and, as resources permit, adding new calibration targets and criteria. Calibration should be continued as improved data and procedures become available. The report should more thoroughly explain the calibration logic (including utilizing existing modeler notes). This will help the model fulfill the expressed goals.

Verification

According to *Spitz and Moreno* (1996) groundwater flow model verification is "the process of demonstrating that the calibrated model is an adequate representation of the physical system." The qualifier "adequate" is dependent upon the intended purpose(s) of the model. The draft model documentation (*Giddings, et al.*, 2006) states that the LECsR "model will be used primarily to perform predictive simulations of proposed water resource projects and/or operational schemes. It will also be used as an interpretive tool for the Modeling Team by identifying data gaps in aquifer characteristics, hydrogeologic, stratigraphic and hydrologic parameters, and producing water budgets and groundwater flow maps to better understand the surface/groundwater system." The Panel considered these and other expressed purposes when evaluating the model verification as one aspect in determining overall model usefulness.

Groundwater model verification is intended to provide additional confidence in the completed model calibration by demonstrating that the model will perform within acceptable limits when subjected to boundary conditions and/or hydrologic stresses different in timing and/or magnitude from those used to calibrate the model. In the absence of verification, a groundwater model is untested beyond the exact conditions used in the calibration and its usefulness to make other than general predictions is questionable (*Spitz and Moreno*, 1996). *ASTM* (2002a) states that model verification protects against "over-calibration" which is fine-tuning of input parameters to a higher degree of precision than is warranted by the knowledge or measurability of the groundwater system and results in artificially low residuals. Without verification, the artificially low residuals might result in an unwitting overstatement of the accuracy of predictions made by the model.

For LECsR model verification the Modeling Team presumably followed the discussion presented by *Anderson and Woessner* (1992). The calibration period for the model was 1986-1999, roughly 13 years of daily data. The time period used for model verification was September 1999 through December 2000, representing 16 months of daily data.

The LECsR model verification process consisted of adding the verification data set (i.e., September 1999 through December 2000) to the end of the calibration data set and running the model for the entire calibration plus verification time period. The simulated responses over the verification period were split out from the calibration period and statistically analyzed independently from the results from the calibration time period. The Panel believes that the Modeling Team model verification procedure is acceptable and is consistent with general groundwater modeling practice.

The global statistical results from the model verification are not appreciably different than those same statistics resulting from the final model calibration although the mean error (ME) resulting from the verification simulation is 0.11 ft, versus 0.00 ft for the calibration simulation. The global statistics represent a temporal, as well as spatial averaging process and thereby smooth the ensemble of individual water level residual statistics. The significant difference between the time period for calibration (13 years) and verification (1.33 years) is problematic in that the verification period may not be substantially different in terms of hydrologic stress and/or system operational changes from the calibration period. Consequently, the verification period may not be "challenging" enough to determine how robust the model is in accurately responding to extreme stresses on the system. The Modeling Team addressed this concern in response to Panel questioning saying that the Modeling Team is in the process of increasing the verification period. The Panel agrees that, even though the verification period was relatively short in relation to the calibration period, late 1999 through 2000 (verification period) was a time of moderate drought over which the model performed reasonably well as evidenced by the global model verification statistics.

The Modeling Team did not evaluate the outcome of LECsR model verification against "soft" targets. Soft targets include system data that may not have undergone the same quality assurance analysis as "hard" targets (i.e., the formal calibration targets) but are nevertheless meaningful in further verifying the overall performance of the model. Soft targets could include a periodic (i.e., time discrete) water levels in wells located in areas where hard targets are sparse, surface water stages in WCA's or the EAA determined from anecdotal information but that are nevertheless reliable estimates, or wetland hydroperiods determined from water level data or biological indicators. The Panel encourages the Modeling Team in future modeling efforts to identify and take advantage of soft information that may further enhance model evaluation and acceptance beyond the formal hard target data used in the calibration/verification process.

Another form of model verification is to evaluate the response of the model over a specific time period at a specific location that has been subjected to a change in stress. This type of verification is intended to demonstrate that the model can accurately predict the response of the hydrologic system to a change in stress similar to those that will occur when the proposed projects are implemented. This verification involves a subset of the targets (spatially and temporally) used for the calibration and prevents “masking” of local inaccuracies by the multitude of targets that may not be affected by a local change in stress. At the request of the Panel, the Modeling Team performed limited verification involving the shifting of pumping at Miami-Dade County wellfields. The results of this analysis were generally positive. The Panel encourages the Modeling Team to identify other subsets of data involving stress changes and use them for verification purposes. This type of demonstration is important considering that one of the key objectives of the model is to predict the response of the hydrologic system to various water supply projects.

In the final model documentation the Modeling Team is encouraged to include cloud plots of observed water levels versus simulated water levels showing deviation from a 1:1 correspondence for both the final calibration and verification simulations. Cloud plots are valuable tools for visualizing the global simulation outcome, any systematic bias, and the extreme outliers.

Sensitivity Analysis Methodology and Results

After model calibration, sensitivity analysis quantifies the effect of input parameter variability on model calibration, prediction, or conclusions (*ASTM*, 2002b). The Modeling Team identified suitable model input parameters to be varied, and ranges for variation. In each sensitivity analysis simulation, the Modeling Team singly increased or decreased values of one of 36 input parameters before otherwise repeating the calibration run. The modification of a single input parameter, such as the hydraulic conductivity of aquifer layer one, required that the calibrated hydraulic conductivity value in each layer one cell be multiplied by the same real number. Sensitivity simulations were from January 1986 to December 1995. This portion of the calibration period has conditions ranging from very dry to very wet.

Varied input parameters included those related to recharge, evapotranspiration, aquifer transmissivity and storage, and surface-ground water interaction. The Modeling Team termed the simulated value differences between the new runs, and the calibration run, as ‘residuals’ (in literature, these are commonly termed ‘sensitivities’). For all target head locations, the Modeling Team reported the resulting head residual mean, maximum, minimum, and standard deviation. Because wetland areas include additional flow processes and parameters, the Modeling Team also reported head sensitivity statistics separately for wetland and developed (urban) areas.

In the report, sensitivity run heads are presented only by comparison with heads from a calibration run (for the same period). Because the sensitivity run heads were not compared with observed heads, it is difficult to know whether the calibrated parameter values can be improved. The Panel recommends that the Modeling Team also report results using criteria used during calibration. This will show whether a sensitivity run is better than the calibrated run.

The Panel noted in Table 18 that multiplication of Kadlec coefficients by 1.5 and by 0.7 caused identical frequency distributions of head changes. The Modeling Team corrected this apparent error during the peer-review and these results should be included in the final model documentation. Similarly, the subsection on horizontal hydraulic conductivity of the muck/aquifer underneath water body indicates that both increasing and decreasing this conductivity value cause changes similar to each other. The sensitivity analysis generally yielded results that make intuitive sense—head increases usually occur when expected, as do decreases. Predicted heads are likely to increase if a parameter change increases nearby water availability and likely decrease if a parameter change decreases nearby water. Thus, predicted heads in wetland areas tend to decrease with any change that increases evapotranspiration or decreases recharge, and tend to increase if evapotranspiration decreases or recharge increases.

To parameters involving or near surface water and upper aquifer strata, wetland area heads were usually more sensitive than urban area groundwater heads. Predicted groundwater heads in urban areas are generally most sensitive to increases and decreases in hydraulic conductivity of layers two and three, and to decreases in river conductance. Individual wells near significant hydraulic stimuli can be sensitive to nearby specific yield.

The changes in residuals of the sensitivity runs ranged from insignificant to significant. The report does not discuss sensitivity results using standard ASTM sensitivity type terminology. Thus, the report does not mention whether any of the sensitivity runs seemed to invalidate the model or exhibit Types III or IV sensitivities (*ASTM*, 2002b). However, the scope of the model documentation does not include predictive simulations whereas determination of ASTM sensitivity types requires an assessment of sensitivity of predictive simulations. Therefore, this type of sensitivity analysis may have to be performed at a later date when predictive simulations have been performed.

More detailed field observations and calibration targets might be required before a sensitivity analysis would show whether the model becomes invalid for a particular site-specific purpose. For example, assume that a model goal is to be able to predict whether fresh water aquifer head is sufficient in a location to prevent increase in salt water intrusion. Even under steady flow conditions intrusion can be significantly affected by several assumed input parameters. If using the current set of calibration targets, several different combinations of input parameters might yield comparable calibration statistics. However, including additional targets might discredit some of the previously acceptable sets of input parameters. It is important to evaluate individual well sensitivity in addition to global sensitivity. Having many targets can mask the sensitivity of local targets if only evaluating global calibration criteria.

Probably because of system complexity, the Modeling Team did not evaluate sensitivity to coordinated parameter changes. Such evaluation could help determine whether there are other (non-unique) sets of aquifer parameters that would yield calibration statistics comparable to those of the calibrated set, while being more realistic and robust.

Including new calibration targets in areas currently without targets might or might not cause changes in assumed calibrated parameter values.

This Peer Review Report includes some recommendations that the Modeling Team is already implementing, and some that might be implemented in the future. Some can involve re-calibration (additional targets, new evapotranspiration computations, new conductance, conductivity, and Kadlec parameters, new spatial and temporal pumping distributions). Especially if conducting a new calibration, the Panel recommends that the Modeling Team also perform a new sensitivity analysis, using the entire calibration period instead of a portion thereof. It is recommended that the sensitivity analysis results include differences from observed field values. This can build confidence that calibrated parameter values lie between the extreme values used in the sensitivity analysis. If possible, the new analysis should include coordinated changes to multiple parameters simultaneously. If available for the SFWMD MODFLOW implementation, using an automated software package, such as SENS, is recommended.

CHAPTER 4
Model Documentation

Description of Model Documentation

The Panel reviewed the March 2006 version of the draft Lower East Coast SubRegional Model Documentation (*Giddings et al.*, 2006). This report included text, tables, figures, and three Appendices. The Panel understands that the purpose of the model documentation is to provide a detailed overview of the model, the process by which the model was developed, and results of the calibration and sensitivity analysis. It is also understood that the documentation is not a user's manual and therefore does not present the mechanics of model execution or detailed instructions on data set modification.

Comprehensiveness

Anderson and Woessner (1992) discuss the requirements and suggested format for documentation of groundwater modeling projects. These requirements include:

- The purpose of the model,
- Formulation of the conceptual model,
- Governing equation,
- Boundary and initial conditions,
- Aquifer parameters,
- A list of assumptions and the field data to formulate the conceptual model, to set reasonable ranges in parameter values, to calculate initial conditions, to calibrate the model and to estimate the water balance,
- Model grid and location of boundaries and internal sources and sinks,
- Calibration results and sensitivity analysis, and
- Results of predictive simulations.

With the exception of documenting the results of predictive simulations (discussed below), the Panel finds that the Modeling Team has fulfilled these requirements such that the scope of the documentation is appropriate.

The model documentation does not include a section describing model predictions for two primary reasons. First, the model is intended to be used for a variety of purposes and therefore the model documentation does not focus on any specific application. Second, the model has not yet been applied to develop predictions. Although the Panel agrees that non-inclusion of model predictions in the documentation is appropriate, we recommend inclusion of a section describing in general terms the mechanics of how the model will be used in a predictive mode. This section should have an explanation of how the model will be adapted to make future predictions and a general assessment of its usability in this regard. This section of the report should also describe how inputs of future data (precipitation, canal stage, boundary conditions, pumping, etc) will be derived and included in the model. It was not initially clear to the Panel from the draft documentation that some inputs for the predictive simulations will be developed from the regional SFWMM.

Organization

Anderson and Woessner (1991) and *ASTM* (2000) each provide suggestions and guidelines on the organization of model documentation reports. The Panel believes that the optimal organization is often project or model-specific but that the content suggested by these references should be included. With the exception of the section on guidance on model predictions (discussed in the prior section) the Panel finds that the content of the report is comprehensive. The Panel made several suggestions regarding additional clarifying text to be included in the report. These are contained in the list of questions and answers included in Appendix B of this review. The Panel finds that the text is generally well organized.

Format

The Panel finds that the format of the document is appropriate and does not need to be modified. Additional comments and recommendations on the text, figures, tables, and references are provided below.

Text

The Panel finds that the clarity of the model documentation is high and that the document is readable. However, numerous comments and suggestions were made in the list of questions (Appendix B) to supplement the model documentation with detailed explanations and clarifications. The Panel recommends that the final model documentation include this supplemental text. In addition, the version that was reviewed contained many typographical errors and grammatical/sentence structure errors. Many of these errors were highlighted by the Panel in their list of questions (Appendix B). The Panel recommends that an extensive technical edit be conducted to correct these and any new errors that might arise from adding or modifying text.

Figures

Numerous figures are included in the documentation to supplement the text and to describe model features or results. The Panel finds that the Modeling Team's use of figures and format is appropriate.

The Panel requested additional figures from the Modeling Team to assist them in their review. Many of these figures provide highly technical information that, while useful for the peer review, are not appropriate for inclusion in the model documentation. However, the Panel recommends that the additional figures discussed in the body of this report and the list of questions/comments (Appendix B) be included in the model documentation.

Tables

Numerous tables are included in the documentation to provide detailed numerical data regarding the model. The tables currently in the documentation are generally appropriate and should be included in the final model documentation. The Panel recommends that a list of tables be included in the documentation for reference purposes.

References

The Modeling Team included a comprehensive list of references in the model documentation. A cursory review and cross-checking of the references indicates many referencing errors (inaccurate dates, author lists, references not called out, etc). The Panel recommends that the Modeling Team carefully cross-check the text of the report with the reference section.

CHAPTER 5
Responses to Specific District Questions

The Modeling Team requested that the Panel address 21 specific topic questions that were outlined in the scope of work. Individual members of the Panel developed independent responses (Appendix C) which have been combined into this single list that states the collective response of the Panel to these questions.

Question	Response
1. Draft LECsR Documentation	
A. Does the documentation provide a clear and appropriate description of the LECR model?	YES, the documentation provides a clear and appropriate description of the LECsR model for the most part. There are some part of the document that should be enhanced with clarifications noted in Chapters 2, 3, and 4 (of this review), and list of questions.
B. Are the objectives of the documentation clear?	YES
C. Are the objectives met?	YES, the objectives of the documentation, as outlined in the Introduction, are met.
D. Is the documentation readable?	YES, there are many typographical and grammatical errors throughout the documentation that should be resolved, particularly in Chapters 3 and 4.
E. Are additional levels of detail required to serve the intended objectives?	YES, as requested in the Panel's list of questions and in various locations of this review.
F. After reading the documentation are you able to understand the purpose, scope, strengths, and limitations of the LECsR model?	YES. Some of the strengths may be inferred, although they are not explicitly addressed. Model limitations are addressed, but this section could be expanded.
G. Does the scope and format of the documentation need to be modified or expanded?	NO. However, a section on how the model will be used to make predictions should be added as noted in Chapter 4 (of this review). One panel member felt that Chapter 4 of the draft model documentation needed significant revision.
2. Model Implementation	
A. Based on the documentation and presentations by the District, are the modeling techniques and methodologies used in the model appropriate for the temporal and spatial scale of the model?	YES. There are some data limitations with regard to pumping (monthly data, not categorized by individual well) that are not consistent with the fine temporal and spatial aspects of the model. There are more sophisticated spatial interpolation methodologies that could be incorporated in future versions of the model.
B. Is the conceptual model defensible?	YES.
C.a. Does the LECsR model include all the important physical and hydrological processes necessary to address sub-regional scale water resource issues in south Florida?	YES, representations of the relevant processes are included. The report should explain hydrologic and predictive needs for which it should and should not be applied at this time.
C.b Are the physical features and hydrologic processes represented adequately?	(See specific categories below)
C.b.i. Groundwater flow?	YES.
C.b.ii. Flow in and through wetland systems?	YES, on a sub-regional, but not local scale.
C.b.iii. Climatic input?	YES.
C.b.iv. Boundary Conditions?	YES.

Question	Response
C.b.v. Applied Stresses	YES. There are some data limitations with regard to pumping (monthly data, not categorized by individual well) that reduce accuracy over short analysis periods and near wellfields.
C.b.vi. Topography	YES. The Modeling Team appears to be aware of the different levels of accuracy that are present across the model area. The impact of this variability has not been assessed.
C.b.vii. Surface water/groundwater interaction	YES. However, the water budget with regard to groundwater seepage to/from canals was assessed only in one area in the report (and at some other areas at the request of the Panel). Calibration of surface water/groundwater interaction needs to detailed in the model documentation. Several recommendations were made that the Modeling Team adopted that improve some of the aspects of groundwater/surface water interaction.
3. Model Calibration	
A. Does the model appear to be adequately calibrated relative to other commonly employed calibration methods?	YES. Groundwater levels in wells and surface water are generally well calibrated. However, a demonstration that flows to/from canals are calibrated is needed. Additional soft calibration targets are desirable to enhance confidence in the model.
B. Are there any other calibration criteria or methods that you recommend be used?	YES. A demonstration that flows to/from canals are calibrated is needed. Additional calibration to conditions or stresses similar to those that will be encountered in the predictions would provide confidence that the model can meet its objectives (see further discussion in Chapter 3 or this report). The Modeling Team is adding additional head targets and soft calibration targets in subsequent versions of this model.
C. Is additional sensitivity analysis needed for the intended purpose of the model?	NO. The sensitivity analysis performed is generally adequate. However, classification into ASTM types 1-4 would be useful to indicate limitations of predictions and as a guide to future data collection. Sensitivity analysis should be performed as a part of model recalibration.
D. Are the verification methods appropriate?	YES. However, the verification is somewhat limited by the short period of time (1 yr) relative to the calibration period (14 yrs) and the similar climatic and stress conditions that are imposed during the verification period. Verification should be performed after each recalibration of the model.
E. Does there appear to be any model bias throughout the range of model predictions?	NO, not of significance. For the calibration, there is a slight tendency to under-predict (modeled water levels lower than observed) wet season groundwater levels and over-predict (modeled water levels higher than observed) dry season groundwater levels. The magnitude of this bias is small relative to groundwater level fluctuations. Extreme conditions may not be simulated as well as normal conditions.
4. Overall Appropriateness of Model	
A. What are the model strengths?	Strengths of the model include: 1. a comprehensive model incorporating the hydrostratigraphic units and groundwater/surface water connections, 2. the detailed temporal treatment of hydrologic stresses, 3. a huge data base (real data) upon which it is built , 4. a well understood conceptual model, 5. prior knowledge from calibration of county-wide models, 6. it is reasonably well-calibrated to groundwater and surface water levels, 7) Ability to rapidly modify code and develop data to improve predictive capability.

Question	Response
B. What are the weaknesses of the model?	Weaknesses of the model include: 1) The accuracy to which the LECsR model can simulate the response of the groundwater system to some types of future hydraulic and/or water management structure changes is unknown. The model calibration and verification do not address all possible future changes that may occur within the model domain as these would be virtually impossible to anticipate, 2) there appears to be difficulty confirming some surface water – aquifer seepage rates, 3) there is some spatial bias in the initial calibration due to the non-uniform spatial distribution of the formal calibration targets (i.e. heads at the original 195 wells and surface water gages), 4) inaccurate ground surface elevations at some initial and new head observation locations cause uncertainty in assumed model parameters and in hydroperiod prediction. 5) the temporal and spatial resolution of well pumping data could be better matched the finer temporal and spatial scale of the LECsR model
C. Are there any deficiencies of the model?	NO. In future versions of the model, a more sophisticated approach than that currently used could be employed to develop spatial distributions of parameters such as hydraulic conductivity. However, calibration to flows to/from canals would provide greater confidence in the model.
D. Is the model suitable and defensible for the applications detailed in the documentation?	YES, based on the model calibration. However, the model's predictive accuracy has not been directly assessed. Unsure of how well it predicts hydroperiods, heads away from targets, surface flows not reported in the calibration. Post auditing of projects as they are developed and updating of the model are crucial to making this model an accurate predictive tool.

CHAPTER 6
Overall Findings and Recommendations

Findings

Findings from the peer review are discussed in categories of the documentation, model development, model application, and strengths and weaknesses of the model.

The Panel reviewed the March 2006 version of the draft Lower East Coast SubRegional Model Documentation. This report included text, tables, figures, and three appendices. The Panel understands that the purpose of the model documentation is to provide a detailed overview of the model, the process by which the model was developed, and results of the calibration, verification, and sensitivity analysis. It is also understood that the documentation is not a user's manual and therefore does not present the mechanics of model execution or detailed instructions on data set modification. The Panel finds that the Modeling Team has fulfilled the requirements of commonly accepted standards for model documentation such that the scope of the documentation is appropriate. The Panel finds that the text is generally well organized, the format of the document is appropriate, and that the clarity of the model documentation is high. Finally, the Panel finds that the Teams use of figures and tables is appropriate and serves to clarify and enhance the document. The Panel made several editorial suggestions and comments that are included in the peer-review report.

With regard to model development, the Panel believes that the Modeling Team followed accepted practice in developing and describing the conceptualization of the model and that they incorporated all major (and many minor) components of the surface and shallow aquifer water resources system in the model. The Panel finds that the model construction (boundary conditions, discretization, layering, parameterization) are reasonable and appropriate for the model's intended application.

Calibration is the process of refining a groundwater model representation of the hydrogeologic framework, hydrogeologic and hydraulic properties, and boundary conditions to achieve a desired degree of correspondence between the model simulations and observations of the groundwater flow system. An accurate and comprehensive calibration provides confidence that the model will provide accurate predictions of future behavior or response to hydrologic stresses. The Panel finds that the Modeling Team followed standard modeling protocols in calibrating the model. The Modeling Team has performed a comprehensive calibration to many (195) groundwater and surface water level targets that were measured on a daily basis for a 14 year period. Although the Panel found this calibration effort impressive, there was general consensus that additional targets and methods would provide additional confidence in the model for specific applications of the model.

The Panel believes that the strengths of the model include: 1) a well-developed and understood conceptual model that is based on a comprehensive data base and knowledge from prior model applications, 2) detailed physical and temporal representation of stresses on the hydrologic system, 3) a good calibration to 195 groundwater and surface water levels that were measured on a daily basis for the 14 year calibration period, and 4) ability to rapidly modify code and develop data to improve predictive capability.

All groundwater models have weaknesses and legitimate use limitations. The LECsR model is no exception. The accuracy to which the LECsR model can simulate the response of the groundwater system to some types of future hydraulic and/or water management structure changes is unknown. The model calibration and verification do not address all possible future changes that may occur within the model domain as these would be virtually impossible to anticipate. However, to the extent practical, the calibration does include consideration of the response of the groundwater system to shifts in wellfield demand and flow into and out of existing impoundments.

Other weaknesses are: 1) there appears to be difficulty confirming some surface water – aquifer seepage rates, 2) there is some spatial bias in the initial calibration due to the non-uniform spatial distribution of the formal calibration targets (i.e. heads at the original 195 wells and surface water gages), and 3) inaccurate ground surface elevations at some initial and new head observation locations cause uncertainty in assumed model parameters and in hydroperiod prediction. The Modeling Team is addressing these three issues by considering additional hard and soft targets and other anecdotal information in an expanded model verification. These additional hard and soft calibration targets will be incorporated directly in model recalibration to be presented in the final model documentation.

Finally, it would improve model validity if the temporal and spatial resolution of well pumping data better matched the finer temporal and spatial scale of the LECsR model. Raw pumping data are typically reported monthly and aggregated as total well field withdrawal. With daily pumping rates unavailable, the Modeling Team uniformly distributes the reported monthly data to estimate daily pumping rates and, therefore, may not match actual daily pumping. The Modeling Team will address this issue to the extent practical and focus on key water supply utilities in the model recalibration to be presented in the final model documentation.

At the request of the Panel, the Modeling Team expanded upon the limitations of the LECsR model that were presented in the draft model documentation. The Panel concurs with the limitations that were identified by the Modeling Team: 1) the LECsR Model does not perform hydraulic routing, and therefore cannot size a canal or estimate overbank flooding, 2) the LECsR Model does not address local-scale issues, such as relocating an individual well or sizing a wellfield, 3) the LECsR Model does not address seepage through a levee, but can address flow under a levee, 4) the LECsR Model does not address event-based hydrological issues, such as predicting peak discharges, and 5) if significant stress is proposed near the western model boundary along WCA-3A, western boundary effects may result from a shift in the water table and it is recommended that the boundary conditions (at that location) are re-evaluated or the model domain is extended.

Recommendations

The Panel made many recommendations to the Modeling Team during the course of the review. The Modeling Team has been responsive to some of these recommendations within the schedule of the peer-review process by conducting requested analyses or by considering inclusion of various additions to the final model documentation. The key recommendations are:

1) Utilize a more sophisticated spatial interpolation methodology than the Inverse Distance Weighting method used for hydraulic conductivity.

2) Adopt the new potential evapotranspiration standard of grass (as opposed to wet marsh crop) when appropriate.

3) Broaden the scope of the calibration to include: a) calibration to the larger set of targets (than the 195 daily targets presented in the draft model documentation) discussed during the peer-review process to cover areas that have limited spatial coverage, b) the recent work performed in demonstrating that the model reasonably matches canal/aquifer seepage rates and/or flow to tide, c) calibration to "soft" targets, including the recent work by the Modeling Team to verify the match to wetland hydroperiods, and d) evaluate and present the calibration metrics for specific periods in time in addition to the metrics presented for the entire calibration period.

4) Provide a more comprehensive description of the calibration process than is included in the current documentation. This description should systematically and perhaps chronologically elucidate the logical decisions and reliance on prior information from the county-wide models. *Anderson* (1983) suggests that the thought process needed when applying [and developing] a model should lead to decisions, not necessarily the model answers. It would be useful, to the degree possible, to document the thought process that went into the LECsR model.

5) Consider expanding the verification period to a length greater than the currently used 14 month period. The panel expressed some concerns that this verification period may not be substantially different in terms of hydrologic stress and/or system operational changes from the calibration period. Consequently, the verification period may not be "challenging" enough to determine how robust the model is in accurately responding to extreme stresses on the system.

6) Strive towards verifying that the model can accurately predict the effect of specific projects (as outlined in the model objectives) or hydrologic responses (wetland hydroperiods, canal seepage changes) by isolating and evaluating subsets of the existing calibration targets based on location and time of an

imposed stress on the system. With regard to wetland hydroperiods, additional information, particularly more detailed topographical data, may be required for hydroperiod prediction.

7) In lieu of the previous recommendation, which may not be possible because significant changes to the system have not yet occurred, conduct post-audits of the ability of the model to predict these changes. The post-audits will either provide additional confidence in the model or suggest ways in which the model should be modified. These post-audits should be a part of an ongoing model maintenance task that will provide continuous improvement of the model's predictive capability.

8) To conduct a comprehensive technical edit of final document.

9) Add additional clarifying text and figures as discussed in the body of the peer review document and list of questions.

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APPENDIX A
Minutes from Meetings

Meeting Minutes from the Kickoff Meeting for the LECsR Model Peer Review

March 13, 2006
Richard Rogers Conference Room – B1 Second Floor
SFWMD, 3301 Gun Club Road, West Palm Beach FL

Participants:

Mr. Pete Andersen, GeoTrans, Chairperson
Dr. Richard Peralta, Utah State University Panel Member
Dr. John Shafer, University of South Carolina, Panel Member

Jeff Giddings, Resource Evaluation and Subregional Modeling Division, Water Supply Department SFWMD
Laura Kuebler, Resource Evaluation and Subregional Modeling Division, Water Supply Department SFWMD
Pete Kwiatkowski, Resource Evaluation and Subregional Modeling Division, Water Supply Department SFWMD
Angela Montoya, Resource Evaluation and Subregional Modeling Division, Water Supply Department SFWMD
Hope Radin, Resource Evaluation and Subregional Modeling Division, Water Supply Department SFWMD
Kevin Rodberg, Resource Evaluation and Subregional Modeling Division, Water Supply Department SFWMD
Jorge Restrepo, FAU

Jerry Cook, Palm Beach County ERM
Maged Hussein, USACE
Kathleen Jones, SDI (Peer Reviewer for IMC)
Steve Lamb, MFL
Dan Song, USACE
Tom Tessier, ARCADIS
Virginia Webb, Miami-Dade Water Sewer Department

(MAS is Model Application Section)

9:00-9:20 Meet and greet.
9:20 Meeting opened by Pete Kwiatkowski. Pete stressed the importance of peer reviewing the LECsR. Pete welcomed everyone.
9:25 -9:35 Introductions around the room – each person stated name and agency/company. Panelists gave a brief overview of their backgrounds.
9:35-9:45. Hope Radin overviewed the timeline for peer review tasks (see SOW.PPT on Web board) and demonstrated how to post to web board and explained how web board will be used to post materials but not to hold discussions. The web board address is:

http://webboard.sfwmd.gov:8080/~gwpeerreview

9:45-10:05 Review of Sunshine rules by Frank Bartolone. Handouts, copies of which are on web board, were given to panelists.
Questions were posed to Frank on Sunshine Laws.

• Panelists may interact with staff but not with each other (except in the Sunshine)
• Panelists may not use staff as a liaison.
• Staff may meet with each other about the peer review.
• All notes from meetings are public record.
• Discussion on Helicopter flight is limited to questions to staff member.
• Panelists may take pictures from the flight. (Pictures can be posted to Web Board.)

Dr. Shafer asked about the political issues in the area. Pete K. responded that there is competition for water. Panelists inquired about various models. Laura K. added there may be competition of which model to use for certain projects. Dr. Peralta asked if there is one source that is trusted more in Florida, such as the USGS. Jeff G. replied that there are many efforts with different project needs. We (SFWMD) are responsible for water supply and permits. Dr. Peralta asked if there are other WMDs on boundaries of the LECsR model who might challenge model. Jeff G. said there are other models which boarder other WMD, but not the LECsR – it is too far from other WMD boundaries.

How will panelists get feedback on Draft agenda for April 4TH workshop to give chair person? Frank stated that staff should ask all the panelists for their input on the agenda.

Pete K. thanked Frank for coming and reminded everyone to follow the Sunshine Laws. We want all rules followed or the peer review process will be invalidated. There are tight timelines that are relying on the completion of the peer review – Loxahatchee Initial Reservations, for one. Please adhere to the time schedule.

Jeff asked that he be called for technical questions and Hope Radin be contacted for administrative parts of the peer review process.

Break 10:05 – 10:15

Hope R. stated that Jeff Giddings's presentation will be posted to the Web board. Jeff began his presentation (Overview of LECsR) and allowed questions by participants during the presentation, instead of afterwards at the designated time.

It was asked if a USGS Model existed in this area and if other models influence the use of LECsR. Jeff responded that no other model covers the whole area at this scale. A panelist asked if the USACE has other models. And if so, why are they not being used? Laura K. responded that there are many modeling efforts in the LEC, especially due to CERP and Acceler8. The primary tool for the regional analysis is the SFWMM; however, higher resolution or project specific tools are needed also. Acceler8 projects need to be done by 2010 and the WSH123 and RSM models are not done. Jeff G. stated that some projects are too small to see results with 2X2 cells. LECsR is commonly used for predictive simulations of site specific projects. The LECsR peer review is not influenced by other models. Pete K. said to focus this review on documentation of this model, not on other models. Water Supply Projects and AWS projects may need modeling done this summer.

Model Application Section had about 20 models being used with limited staff. The decision was made to combine the subregional, county specific models into one model - LECsR. Laura K. informed the panel that the previous subregional models were vertically and horizontally discretized differently. Using a consistent methodology to develop LECsR makes the model easier to manage. Jorge R. added that the model is super-imposable with the SFWMM and that is the reason for the unusual cell size of 704 feet by 704 feet.

Dr. Shafer asked if the previous subregional models were merged. Jeff and Laura re-iterated that the LECsR is not a merge of previous subregional models. Instead, the conceptual model was re-formulated; the model was re-designed and re-calibrated to its current condition.

Dr. Peralta asked how long it took to develop the model. Jeff answered that work has been done on the model for the past 3 years. Laura K. added that this is the first review of LECsR in this state. Originally the model was developed with a 3-year calibration period. Later, management requested that the model be re-calibrated to a longer calibration period since it would be used in a variety of projects.

Jeff stated that the model has been used to evaluate:
• G-160 (2 years ago),
• Hillsboro Impoundment (1 year),
• CERP North Palm Beach County and C111 Spreader Canal (Currently).

LECsR is also being applied in the Initial Reservations for the Loxahatchee River. A panelist asked if a verification of the model could be done based on previous predictive runs. Jeff said that the C4 impoundment would be a good place to test to see if the model simulated the impoundment correctly (before and after construction).

Panelists asked if rainfall influences model predictions. It was clarified by Jeff and Jorge that the model is used for planning purposes and not for operational issues (not real-time). Laura added that typically a relative comparison among runs is accomplished by evaluating a 36 year simulation with historical climatic conditions. Jeff stated that predictive runs look 20 years out for water supply planning and permitting purposes, for example, to evaluate the response to 1 in 10 drought conditions – if water levels drop more to critical level more than once in 10 years it is a problem. It was clarified that LECsR may apply internal boundary conditions from the regional model, SFWMM, but also that boundary conditions in the LECsR may be used in other models.

A discussion ensued regarding the model design. It was clarified that in the Wetland package, Kadlec, K is similar to Manning's n. In the Diversion package, water can be moved instantly through a structure on a daily basis.

Above-ground reservoirs are modeled with the Wetland package in combination with the Reinjection Drainflow (RDF) or Diversion packages. Above-ground impoundments are deeper than typical wetland (not just 1-2 feet deep) and can be up to 8 feet deep. Wetland cells are largely controlled by topography. Topography is very important for model. Laura K. added that the current topography has data quality and data resolution concerns that hopefully will be worked out when the District produces a District-wide topographic data set.

This model simulates the SAS and Biscayne aquifers. We are not modeling Floridan Aquifer System (FAS). There are separate Floridan models. ASR systems can be represented in the model via mass balance approach. Water can be taken out of model and "stored" in FAS and brought back into model.

The RDF package calculates flow from source to sink areas as a function conductance and daily water levels. RDF moves water from one place to another according to a schedule.

Panelists asked for clarification of the in/out water budget in WCA's and ENP areas. Distinction of the arrows (in presentation figure) needs to be explained in the report. Jeff clarified the following:

- LOK is an external source that brings water into the WCA's, which are internal sinks.
- WCA's are internal sources that send water into urban areas (internal sinks) depending upon urban needs.
- WCA's are internal sources and sinks as water is delivered from one to the other.
- South Miami - Dade is an internal source that sends water into ENP (internal sink).

The DIV package calculates flow from source to sink areas by specifying a fixed set of operational rules. A maximum flow is specified as an input. The rules remain fixed for the entire simulation. However, sets of rules may be specified at one location to increase flexibility in water deliveries.

Dr. Shafer asked if flow estimates are just for relative comparisons between model runs and not for operational estimates. Jeff responded that in the Loxahatchee runs, flows were evaluated to see if the brackish water could be pushed back towards the ocean.
G160 is currently the only operational use of flows for model. LECsR output is used as input to a HEC –RAS model.

Dr. Shafer inquired if the saltwater interface has advanced from 1990 to present. Jeff G. responded that MFLs have helped as well as wetter weather in the last 4-5 years.

Panelists asked if the Q3-4 was good marker in determining layers for hydrostratigraphic model layers. Jeff responded that generally it is more areally distributed than the other contacts.

Laura K. noted that we did not discuss the UGEN package. It allows us to use spread sheets for data that changes in time, instead of using the standard MODFLOW list format that requires you to repeat the data over and over. This package helps us manage data, decrease disk storage and speeds up model execution.

It was re-iterated that the DIV and RDF packages do not use distributed routing. RDF cells have a one to one relationship (number of source cells equals number of sink cells) when moving water. DIV cells have a many to many relationship (number of source cells does not have to equal number of sink cells) when moving water

Canal cells can be specified as sources and sinks. When this option is used, routing is done using the Wetlands package and canal cells must be treated as wetlands. The mass balance is preserved. It was explained how water moves from source to sink areas when operational criteria are met. Andersen asked if alpha and beta remain the same in the canal. Jeff responded that the kadlec exponents, alpha and beta are constant throughout the simulation. Jeff said that UNET is not used in the LECsR because of run-time issues. It would take a long time for the model to complete a 36 year run. Currently, the model takes approximately 1 hour per year.

Panelists asked if GIS coverages would be available. Hope R. responded that GIS coverages for canals will be available as well as other features, as requested.

A panelist asked if the model simulates any extreme short frequency rainfall events. Jeff clarified that the model incorporates extreme events (e.g., Hurricane Irene), but is iterating in a daily basis. 1994 is a very wet year; 1989 is a very dry year.

Peralta asked how many observation wells were near production wells. Jeff stated that about 12 wells did not calibrate near well fields. Some wells are as close as 20 feet from production wells. There are some very large wellfields. The drawdown could exceed 20-30 feet in NPB, but the radial extent is small. In Miami–Dade, the drawdown is shallow, but the cones extend far out. Dan Song commented that in Miami-Dade cones of depression also merge.

Panelists asked if Model Application tried to use irregular grid spacing and if it is possible to refine the problematic zones. Jeff clarified that the purpose of the model is not to simulate local wells. Hope Radin added that it is hard to deal with variable grids. GIS requires uniform grids.

Panelists asked if Model Application could get a better calibration or drive target criteria to a minimum. Jeff and Jorge stated that targets for calibration are based on experience and to a certain extent permitting criteria (i.e., 1-ft rule). Andersen commented that calibration criteria should be based on more than history. Andersen asked if any analysis was done to define the criteria. Shafer asked if this is the best calibration we could do or is this best calibration we could achieve with current resources, data and timelines. Jeff said with more time we could improve the calibration more. Pete K. questioned panelists on the type of calibration criteria they use in their models. Andersen gave an example that in one of his projects out west, the heads fluctuate 800 feet so they have a criteria of 20 feet.

A panelist commented that matching history is one thing, but establishing how well a model predicts is another. If you have a location where you can show that the model did what you expected (such as a storm event) it would be beneficial to document. It would also help to explain "soft" calibration spatially. Shafer asked if we did any qualitative calibration. Jeff responded yes. We have animated movies to show water levels change through time in whole model area. Peralta added that we should not underestimate the importance of soft calibration. Laura K. commented that environmental scientists and biologists typically identify areas where they know the hydropattern for certain species. Model results are then evaluated in those areas also. Jeff clarified that these areas do not contain observation wells. Steve Lamb mentioned that a lot of scientific work has been done in EAA where few wells exist that could be used for soft calibration of model. Jeff and Laura stated that the model is not yet calibrated for flows, except in the North Palm Beach area. However, we are moving in this direction.

A panelist asked how we are going to proceed with a version control of the model. Jeff stated that the base version is the one completed by Monday, 03/13/06. A control version is started after this day. However, when we have new data we want to add it to model so model is updated.

Panelists asked if there are daily flow duration curves, since the monthly ones smooth data. Jeff and Kevin said that we do have daily flow charts for a few locations.

Jeff commented that the model has trouble matching maximum flow values. Flows are calculated based on flow hydrographs and duration curves. A panelist commented that it could be that observed (or measured) flow calculations are less accurate during peak flows and that model is actually simulating flows correctly.

Dan Song asked why the methodology for developing hydraulic conductivity, Vcont and model layering was not discussed. Jeff said these items are documented in the report.

Andersen asked if Model Application is confident in the new MODFLOW packages. Jeff G. stated that most packages have been peer reviewed and published in technical journals. Jorge and Angela stated that we check the mass balance and source code after modifications are made. In the case of the Wetland package, it was checked with an analytical solution.

The panelists asked about if the Hawthorn is a confining unit for base of model. Jeff said yes. It is a 400-600 feet thick clay and phosphate layer.

Maged Hussein asked if primary canals were modeled as Rivers, Drains or Diversions. Jeff answered that the River package was used for managed canals. The Drain package was used for structures, such as weirs. Andersen asked if the document explains when each was used. Jeff responded yes.

Shafer asked about the difference in tidal elevations from north to south. Laura explained that coastal tidal data was developed by Dr. Hagen (UCF) and is modeled data that incorporates sea level rise, but not weather forcing. Laura and Jeff said there is about a 1 to 2 ft difference from north to south.

Break for Lunch 12:35 – 13:20

Mike Voich was introduced to the panelists, since he will be leading the helicopter tour. Jeff drew the helicopter route on a map. (See web board for flight plan.) Voich explained the historical flow, the current operation of canals and the main features of the CERP North Palm Beach project.

The Panelists were thanked for their time and left for the tour with Dr. Jorge Restrepo and Mike Voich. The panelists were reminded to direct all questions to Voich.

Meeting Minutes from the Workshop Meeting for the LECsR Model Peer Review April 4th, 2006

EMD Conference Room – B2 First Floor
SFWMD, 3301 Gun Club Road, West Palm Beach FL

Participants:

Mr. Pete Andersen, GeoTrans, Chairperson
Dr. Richard Peralta, Utah State University Panel Member
Dr. John Shafer, University of South Carolina, Panel Member

Pete Kwiatkowski, Resource Evaluation and Subregional Modeling Division, Water Supply Department SFWMD
Jeff Giddings, Resource Evaluation and Subregional Modeling Division, Water Supply Department SFWMD
Kevin Rodberg, Resource Evaluation and Subregional Modeling Division, Water Supply Department SFWMD
Laura Kuebler, Resource Evaluation and Subregional Modeling Division, Water Supply Department SFWMD
Angela Montoya, Resource Evaluation and Subregional Modeling Division, Water Supply Department SFWMD
Hope Radin, Resource Evaluation and Subregional Modeling Division, Water Supply Department SFWMD
Jorge Restrepo, FAU

(MAS is Model Application Section)

9:00-9:20 Meet and greet.
9:20 Meeting opened by Pete Kwiatkowski. Pete welcomed everyone.
9:25 Pete Andersen summarized status of document. Chapters 1 and 2 are better written then the rest of the document.
Each panelist presented the top questions/issues they wanted answered/clarified during the workshop.
9:30 – 15:30 Questions and Answers

To Do's for District

1. Create figures for RDF's and Diversions - sinks and sources (4/7)
2. Create Flow Paths (4/7)
3. Add observation wells to canal coverage figure.
4. See how to deal with canals that dry up for part of the season in a more realistic manner. Can canals be active in wet season and taken out in Dry? Can a flag be used to turn canals

on and off in the source code?
5. Create ME and MAE maps based on season and for wet, average and dry years (4/14).
6. Show errors on River wells.
7. Suggestion for future – see if satellite images can be used as soft calibration to match hydroperiods.
8. The following items need better documentation: Landuse 2000 Meta Data, Soft Calibration (Soft calibration write up – 4/14)
9. Budgets for canal seepage and canal basin budget (4/17)
10. In the everglades show “fictional wells” to verify that simulated water levels are two feet below land surface. (Show depth of water table in EAA)
11. How would model react to random Gaussian K values?.
12. Beta values in Shark Slough – try to increase to 4.
13. Show northwest wellfield - pompano and Highaleigh (shift in wellfield demand.) (4/14 – 4/17)

Changes in Timeline for Peer review tasks.
Old Date New Date
Task 4. Draft Peer Review Report Panelist report to Chairperson 4/26/2006 5/12/2006

Chairperson report to District
5/3/2006 5/17/2006 - 5/18/2006
District review District comments to Chairperson 5/19/2006 5/23/2006
Task 5 Final Peer Review Report Panelist report to Chairperson 5/30/2006 5/30/2006

Chairperson report to District
6/2/2006 6/2/2006

New teleconference date – 6/6 10:30 – 12:30

15:30 – 17:00 Panelist's discuss report layout and assign tasks.

Introduction (Andersen)
Summary of LECsR model and objectives
Peer review scope
Description of peer review process
Model Conceptualization and Design (Shafer)
Understanding of conceptual model
Representation of hydrologic system (packages, boundary conditions, temporal and spatial discretization, layering)
Methodology of creating model input data sets (data interpolation, assignment of observed data to model data sets)
Calibration and Sensitivity Analysis (Peralta)
Calibration target selection (Shafer)
Calibration process
Results of calibration
Verification (Shafer)

Sensitivity analysis methodology
Sensitivity analysis results
Uniqueness of parameter set
Model documentation (Andersen)
Comprehensiveness
Text
Responses to Specific District Questions (Topic questions, assimilated) (Andersen)
Overall Findings and Recommendations (Andersen)
Appendices (Andersen to assemble)
Scope of Work for Peer Review
Districts Answers to Panels Questions (not discussed at workshop)
Workshop Questions and Answers
Panelist Answers to Topic Questions (Individual)
Minutes from all Meetings

17:00 Meeting Adjourned

APPENDIX B

Questions and Answers on the Model

Districts Answers to Panel Questions

Responses of SFWMD, MAS to Peer Review Panelists

Lower East Coast subRegional (LECsR) MODFLOW Model Documentation

Primary Authors:

Jefferson B. Giddings

Laura L. Kuebler

Jorge I. Restrepo

Kevin A. Rodberg

Angela M. Montoya

Hope A. Radin

Model Application Section, Resource Evaluation and Subregional Modeling Division,

Water Supply Department

South Florida Water Management District

Questions / Comments / Suggestions

General

Comment / Question 1: Add a "List of Acronyms".

Comment / Question 2: Add line numbers to draft documents submitted for review.

Comment / Question 3: Add a "List of Variables" at the beginning of the documentation.

Comment / Question 4: Some figure captions are all upper case while other figure captions are mixed case.

Comment / Question 5: Lack of consistency in terminology. Throughout text there is use of "groundwater", "ground water" and "ground-water", "saltwater" and "salt water", "freshwater" and "fresh water", "surface water" and "surface-water".

Comment / Question 6: Grammatical errors should be corrected. Correct the many places where 'there' is erroneously used instead of 'their'. Document would benefit from use of electronic editors and spell-checker.

Comment / Question 7: The document would benefit from review by a technical editor. The peer review team has made editorial comments in areas where the meaning is unclear or technically inaccurate, but they have not corrected all the typographical errors or restructered sentences. Chapters 3 and 4 are particularly in need of such an edit.

Response 7: Yes, these editorial comments (from Questions 1-7) will be incorporated into the final draft documentation. However, at this time, Model Application Section (MAS) does not have a budget for a technical editor for this project.

Chapter 1

Comment / Question 8: Model Application Section (MAS) employed the modeling steps outlined by Anderson and Woessner (1992). Is the SFWMD aware that the ASTM has developed a number of standards that serve as guidelines for various aspects of groundwater modeling? In particular, D5609-94, Standard Guide for Defining Boundary Conditions in Ground-Water Flow Modeling, 2002; D5610-94, Standard Guide for Defining Initial Conditions in Ground-Water Flow Modeling, 2002; D5981-96, Standard Guide for Calibrating a Ground-Water Flow Model Application, 2002; D5490-93, Standard Guide for Comparing Ground-Water Flow Model Simulations to Site-Specific

Information, 2002; D5611-94, Standard Guide for Conducting a Sensitivity Analysis for a Ground-Water Flow Model Application, 2002; and D5718-95, Standard Guide for Documenting a Ground-Water Flow Model Application, 2000 are relevant to the SFWMD groundwater modeling effort. If the SFWMD is aware of these standards, to what extent were they considered in developing the LECsR model? Does the SFWMD believe that following ASTM guidelines may enhance groundwater model acceptability by various stakeholders?

Response 8: Response 8. The SFWMD did not possess all of the recommended literature from ASTM; the only standard guide that was consulted during model development was D5611-94, which references Anderson and Woessner (1992). The remaining standard guides were purchased on March 28, 2006 after receiving Question 8. After reviewing the standard guides (i.e., D5609-94, D5610-94, D5981-96, D5490-93, D5611-94, and D5718-95), the District believes that the modeling protocol set forth by Anderson and Woessner (1992) is defensible and very similar to that recommended in the ASTM standard guides. The SFWMD believes that using the ASTM guidelines together with the Anderson and Woessner's protocol will enhance the model acceptability and appreciates the recommendation.

Comment / Question 9: Explain how the model will be used to identify "data gaps" in aquifer characteristics, hydrogeologic, stratigraphic (in particular), and hydrologic parameters.

Response 9: This modeling effort required extensive data collection. The model has been used to identify data gaps during the model design, calibration and sensitivity analysis. After assembling the data, MAS was able to identify areas where there were lacking data. For example, Water Supply Department funds projects to help fill some of the data gaps for modeling efforts. Each year, MAS and Hydrogeology Sections conduct geotechnical work (e.g., split-spoon drilling), which MAS incorporates into the model data base.

Comment / Question 10: Are not the physical attributes (i.e., structure and geometry) of the SAS important along with the heterogeneities?

Response 10: Yes, these attributes are important and will be added to the sentence.

Comment / Question 11: There seems to be some confusion regarding whether this is a new model or a combination of the county-wide models. This may be fed by statements such as "the subregional models were modified, updated, and combined into one model…".

Response 11: The LECsR Model is a new model. The sentence now reads, "In order to simulate the majority of the LEC Planning Region, the knowledge-base from the subregional models was updated with current data, the study area was expanded, the conceptual model was re-evaluated, and one, new model, the Lower East Coast subRegional Model (LECsR) was created. The previous, county-wide, subregional models were developed independently with different criteria (e.g., model design, source codes, and calibration periods)."

Comment / Question 12: It may be useful to describe in the introduction how this model will be used to make predictions. There may be some false expectations that it will be capable of predicting what will happen on a specific day, for example. It may be wise to discuss up front.

Response 12: The following paragraph was added (after paragraph 2 on page 6). "This model will be applied for both regional and basin-scale projects. This model will not predict what will happen on a specific day. Predictive applications from the subregional models, including LECsR, evaluate projects relatively – not absolutely. Predictive applications for the LECsR Model use the same long-term (i.e., 36 year), historical, climatic conditions in order to predict the hydrologic responses due to proposed, future stresses or changes to the system."

Comment / Question 13: SFWMD boundary not shown as bold line as indicated in legend.

Response 13: This figure has been revised according to the above suggestion.

Chapter 2

Comment / Question 14: Explain why, as this is a new modeling effort, if it is recommended that grass be used as the reference crop for ET estimation and previous studies have used grass as the reference crop, this study applies the wet marsh crop just because it's been used in previous modeling efforts.

Response 14: This study applies the wet marsh crop largely due to District modeling policy and to be consistent with the regional model. Consistency with the regional model is important when LECsR simulates future conditions and internal boundary conditions are derived from the SFWMM. Additionally, over the years, the District has invested in lysimeters in wet marsh areas. There is a lack of data (e.g., solar radiation) and calibrated parameters (e.g. surface and aerodynamic resistances) that could be used to compute the reference ET for grass. Currently, there is a statewide WMD-USGS effort to develop a methodology to estimate potential and reference evapotranspiration. The completion date is 2007.

Comment / Question 15: Was there any recognition and/or effort to differentiate between the quality of the estimates of hydraulic conductivity (K) based on the manner in which the estimate was derived? For example, K estimates from multi-well aquifer tests are likely more representative (at the spatial scale of this study) than, say, estimates derived from grain size analysis of core cuttings. Assuming all K estimates have the same level of representativeness may lead to a poorer model than using less, but more representative, data that are geostatistically distributed across the model domain.

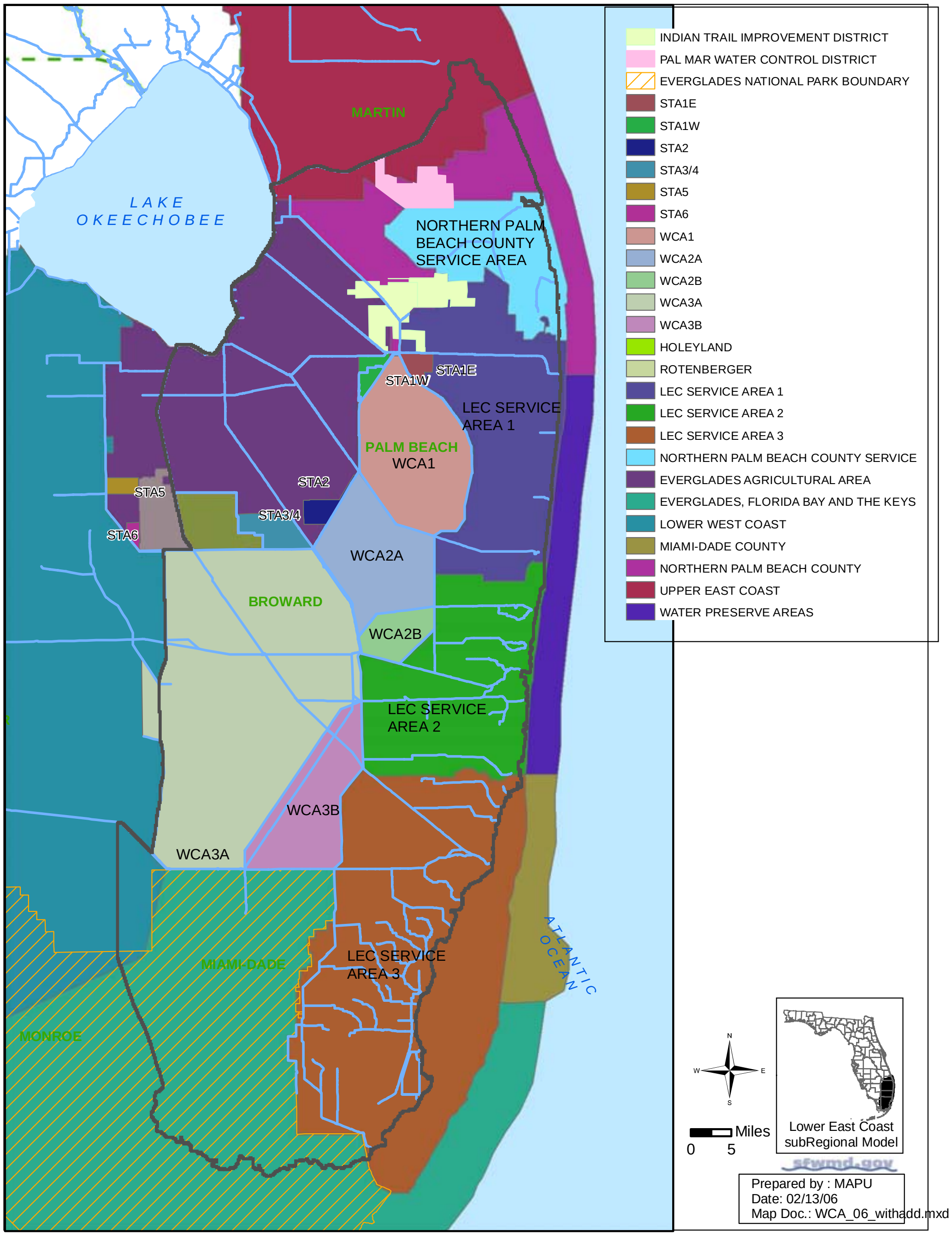
Response 15: There was not an effort to differentiate the between the quality of the estimates of hydraulic conductivity (K) based on the manner in which the estimate was derived.

Comment / Question 16: The text states that a very detailed analysis of hydraulic conductivity (K) was performed on geologic control wells referring to a "complex process". What was this complex process? What were the analytical/testing procedures used? How was K determined for "each section of each geologic control well"? At the beginning of the paragraph a statement is made that there is a lack of APTs in Miami-Dade and Broward counties. Yet, later in the same paragraph the statement is made that previous APTs and new APTs were part of the "complex process" used to estimate K in this part of the study area. This appears to be contradictory.

Response 16: Fish and Fish and Stewart developed continuous hydrogeologic profiles from numerous cores in Dade and Broward Counties. The properties assigned to each foot of the core is a composite result of all the APTs, specific capacity tests, slug tests and laboratory analyses done in Broward and Dade Counties. Therefore, the reason the APTs weren't included in Broward and Dade Counties is that they are already inherent in the geologic control well data.

Comment / Question 17: What are the unclassified areas (white) east and southeast of Lake Okeechobee that are included in the model but not given any designation in the figure?

Response 17: This figure has been revised according to the above suggestion. The white areas were labeled.



Comment / Question 18: The "Southern Slope" is shown inside the study area. However, pg. 11, para. 1 says it is not.

Response 18: The wording, "the Southern Slope" was deleted from the sentence.

Comment / Question 19: Explain what "annual variation is high" means. Is this from year to year, or within a year?

Response 19: In this paragraph, annual variation from year to year is high as shown in Figure 7. Also, annual variation within a year is high as shown in Figure 8.

Comment / Question 20: Can a map be provided that shows more detail of the average annual spatial distribution of precipitation rather than simply stating that precipitation is typically higher along the coast?

Response 20: A figure from the Lower East Coast Water Supply Plan (SFWMD 2000) shows the rainfall patterns.

Chapter 3: Planning Area Description LEC Regional Water Supply Plan - Planning Document

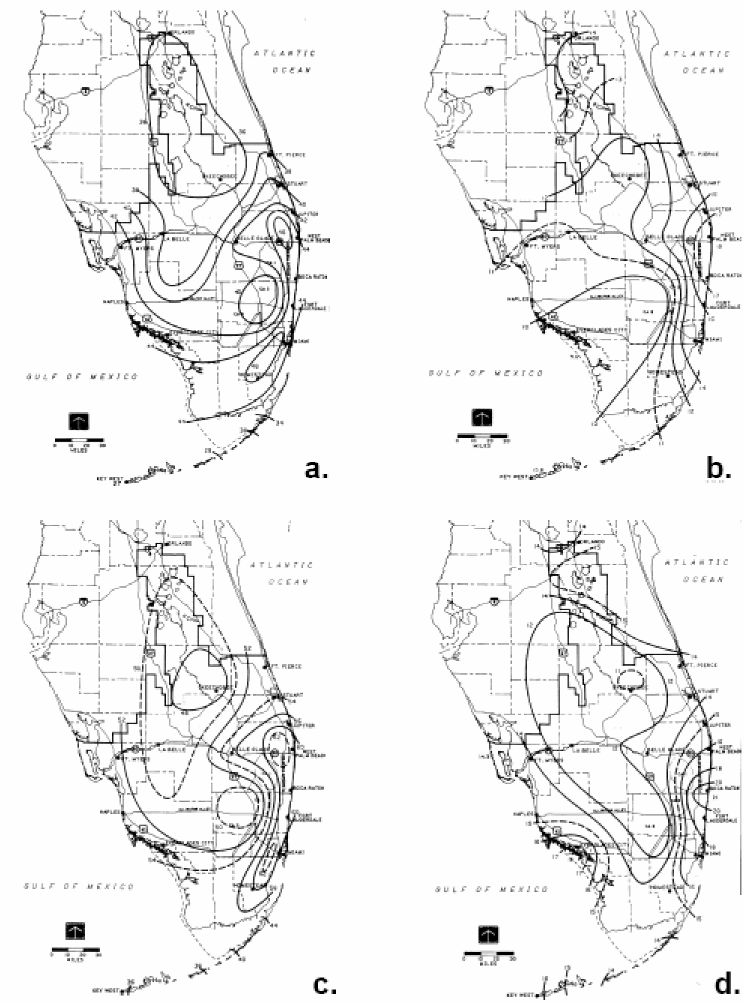


Figure 11. Rainfall Patterns in South Florida, Indicating **a.** Average Wet Season, **b.** Dry Season, **c.** Annual Rainfall Amounts (inches), and **d.** Expected Rainfall During an Extreme Three-Day Rainfall for a 100-Year Return Period.

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Comment / Question 21: How are the data from the ET and precipitation stations distributed areally in the model? Thiessen polygon?

Response 21: The data from the ET and precipitation stations are distributed by creating Thiessen polygons for each data set.

Comment / Question 22: Last sentence in the paragraph is incomplete.

Response 22: The sentence fragment has been deleted.

Comment / Question 23: At this point in the documentation it is unclear whether or not the Peace River Formation (Hawthorn Group) is included in the model domain or forms the boundary of the model domain. Which is correct? If this is the base of the SAS, then is it included in the layer structure of the model? If this represents the boundary of the model (i.e., an aquiclude) then its physical properties that establish it as the boundary need to be discussed.

Response 23: Chapter 2 discusses the conceptual model and describes the study area. The spatial discretization is not described until Chapter 3 (page 91) where the bottom of model domain is defined as the top of the Hawthorn Group. The Hawthorn Group is not part of the model domain because it is non-water-yielding in the study area.

Comment / Question 24: Why isn't the Water Table Aquifer shown in Figure 24?

Response 24: The figure was revised. As explained in the Florida Geological Survey, Special Publication 28, Hydrogeological Units of Florida – the term Surficial Aquifer System replaced the term Water Table Aquifer.

Comment / Question 25: This paragraph indicates there are many locations for which aquifer parameters were developed, other than those shown in Figure 28. Please mark these other locations on the figure. This helps the reviewer know where hard data exists and where it is lacking.

Response 25: This comment will be seriously considered.

Comment / Question 26: What is it about geologic control wells that facilitated a continuous profile of K from ground surface to the base of the SAS? How was this analysis performed? There needs to be more technical detail presented on the development of the various K fields as this is a critical parameter in model performance.

Response 26: We will present more technical detail about this study rather than just citing the authors.

Comment / Question 27: What Kh:Kv ratio is used (10:1 or 100:1)? Is this anisotropy ratio used throughout the model domain or does it vary spatially (regionally)? Is the same ratio used between all layers?

Response 27: The Kh:Kv ratio used in the model is 20:1 and is used throughout the model domain. The same ratio is used between all layers. In Chapter 2, the vertical anisotropy ratio is given for previous studies. In Chapter 3 (on page 105), the ratio is given for the model, since this is the chapter that discusses model design.

Comment / Question 28: What mathematical interpolation scheme was used to develop the continuous hydraulic conductivity fields shown in Figures 29 through 36? The "bulls eyes" in many of the figures (especially Figures 29 and 36) are typically artifacts of the scheme of interpolation of discrete data points. This is especially true if an "inverse distance weighted" approach was used to contour the K data. Were several approaches tried to determine what method would produce the most realistic K fields? Was geostatistics used to create the spatial distributions shown in these figures?

Response 28: Inverse Distance Weighting and Kriging were compared. Kriging allowed the values to shift to extreme unrealistic values – giving negative K values for layers 2 and 3. IDW keeps the values in correct range. We did not use geostatistics on the spatial distribution shown.

Comment / Question 29: Figures 36 and 37 are inconsistent with Table 4. For example, Table 4 lists ag as 1034 mgd, which is about 32% of total use, whereas Figure 36 shows it at 4%, Public water supply is 1097 mgd, which is 34%, while Figure 36 shows it at 53%. Similarly, Table 4 shows Broward County at 539 mgd or 17%, but Figure 37 shows it at 2%. Which is correct? Is there any real doubt about these numbers?

Response 29: The pie charts have been corrected.

Table 4: Permitted Water Use in South Florida, Expressed in Million Gallons Per Day (MGD).

	Broward	Miami Dade	Palm Beach	Martin	Totals
Agriculture	23.8	36.8	761.8	211.8	1034.2
Dewatering	76.4	76.4	274.5	18.4	426.5
Diversion	96.2	0	189.6	0	285.8
Golf Course	18.6	10.3	48.1	8.7	85.7
Industrial	4.3	99.6	32.2	8	144.1
Landscaping and Nursery	37.2	18	47.1	8.4	110.7
Public Water Supply	282.8	497.2	290.7	27.2	1097.9
Totals	539.3	719.1	1644	282.5	3184.9

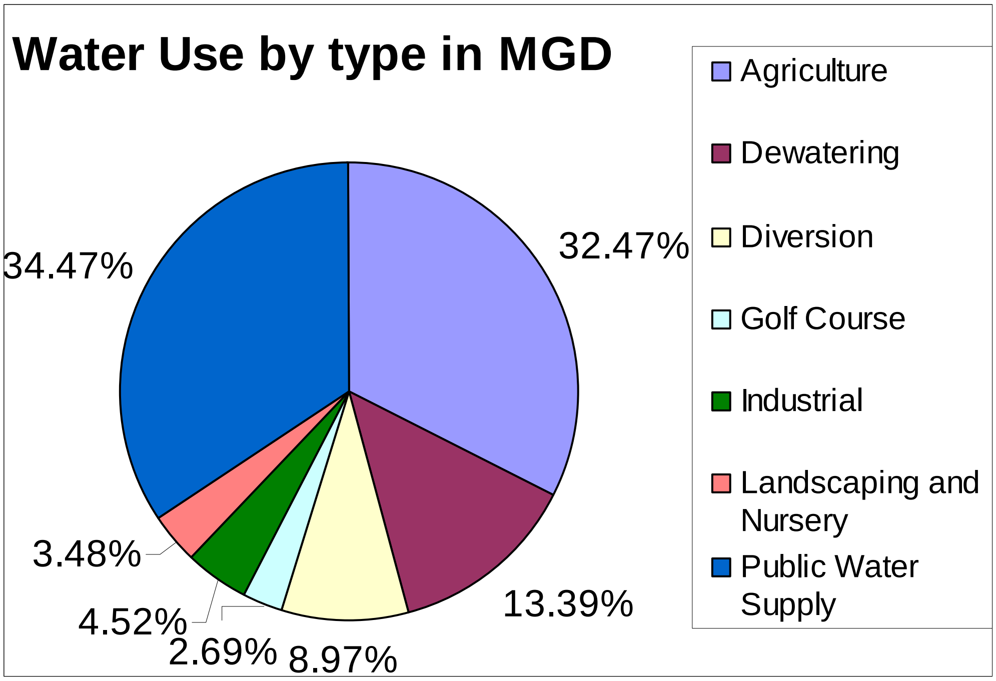


Figure 1. Water Use by Class in 2004.

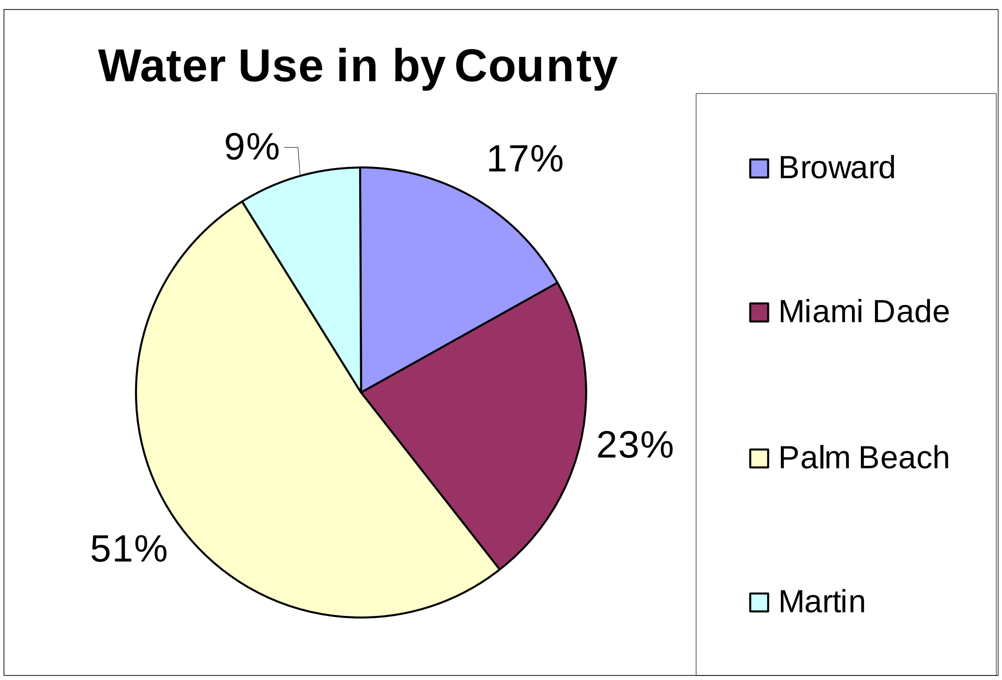


Figure 2. Water Use by County in 2004.

Comment / Question 30: It would be good to clarify how small the largest industrial water use is. Figure 37 on page 66, says industrial use is 1%. One therefore concludes that limestone mining requires less than 1% of total water use. However, is it possible that the water used for limestone mining is actually displayed in Figure 37 under the topic of Dewatering? If so, paragraph 3 on page 65 should be corrected.

Response 30: The pie charts were corrected. The correct industrial use is 4.52%. Dewatering is not included in industrial use.

Comment / Question 31: Please clarify for each county and water use class, the proportions coming from groundwater versus surface water.

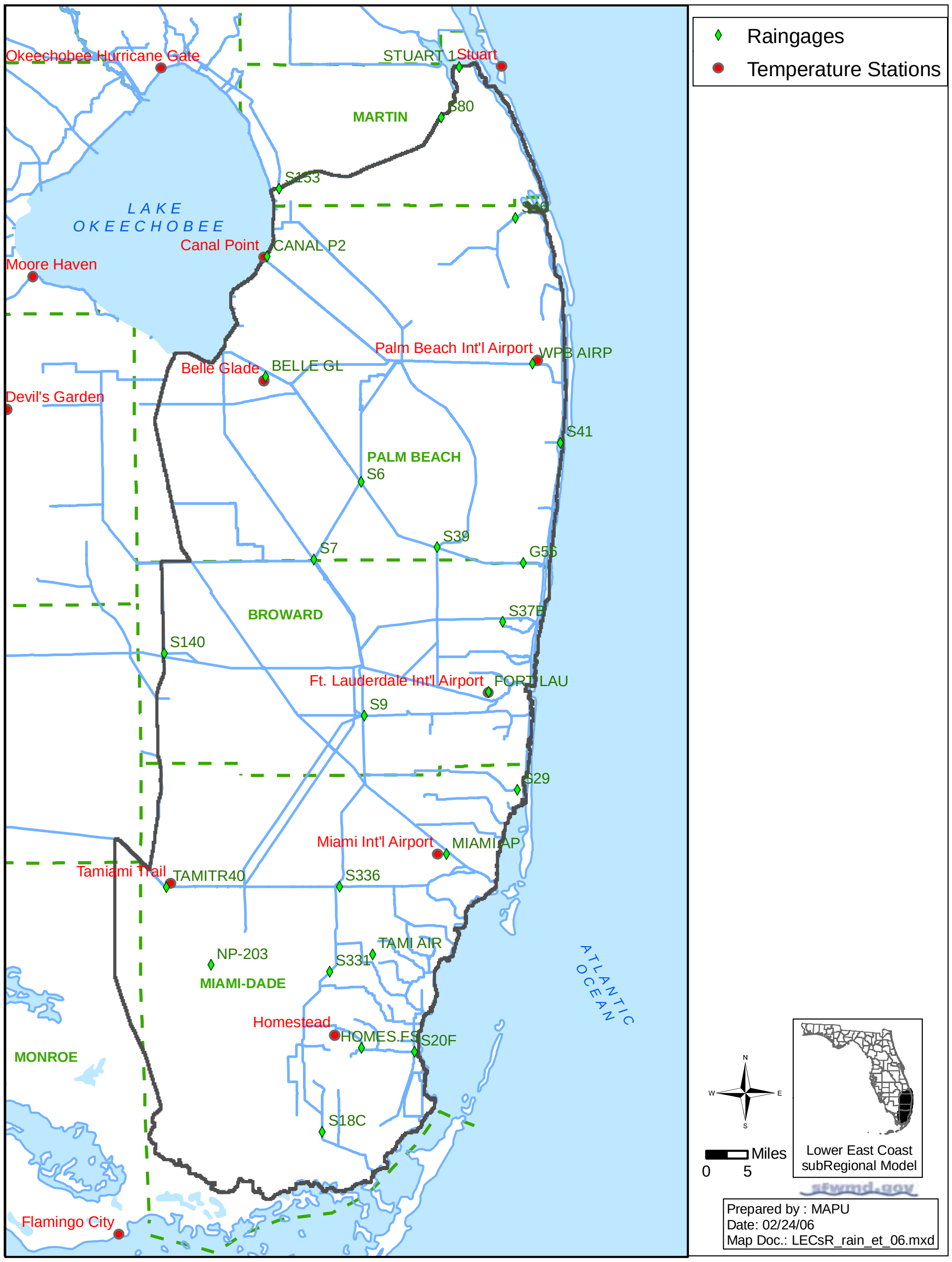
Response 31: The Water Use figures show combined groundwater and surface water use.

Comment / Question 32: Please clarify whether the 'Dewatering' component includes dewatering to allow limestone mining?

Response 32: Dewatering is not included in the industrial use by the limestone mines.

Comment / Question 33: Caption refers to Rainfall and Temp stations, legend calls out Rain and ET stations.

Response 33: The figure was corrected to reflect that temperature values were used to generate ET. Temperature data was the only climatological variable needed for the Simple Method.



Comment / Question 34: There are two separate and different Figure 7s.

Response 34: This was caused by an error in numbering of figures. The figure numbers have been corrected.

Comment / Question 35: The "Mean = 5 in." line is drawn on the graph at about 4.6".

Response 35: The figure has been corrected.

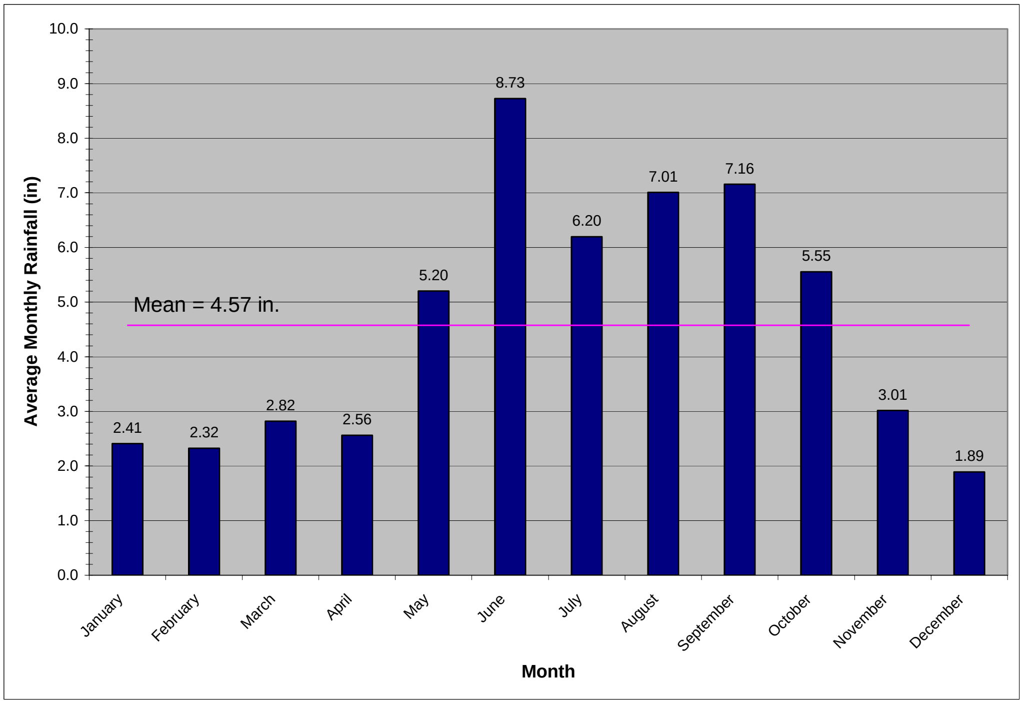


Figure: Average Annual Rainfall (in) from 1965 -2000 by Month.

Comment / Question 36: The "Mean = 57 in." line is drawn on the graph at about 56.5".

Response 36: The figure has been corrected.

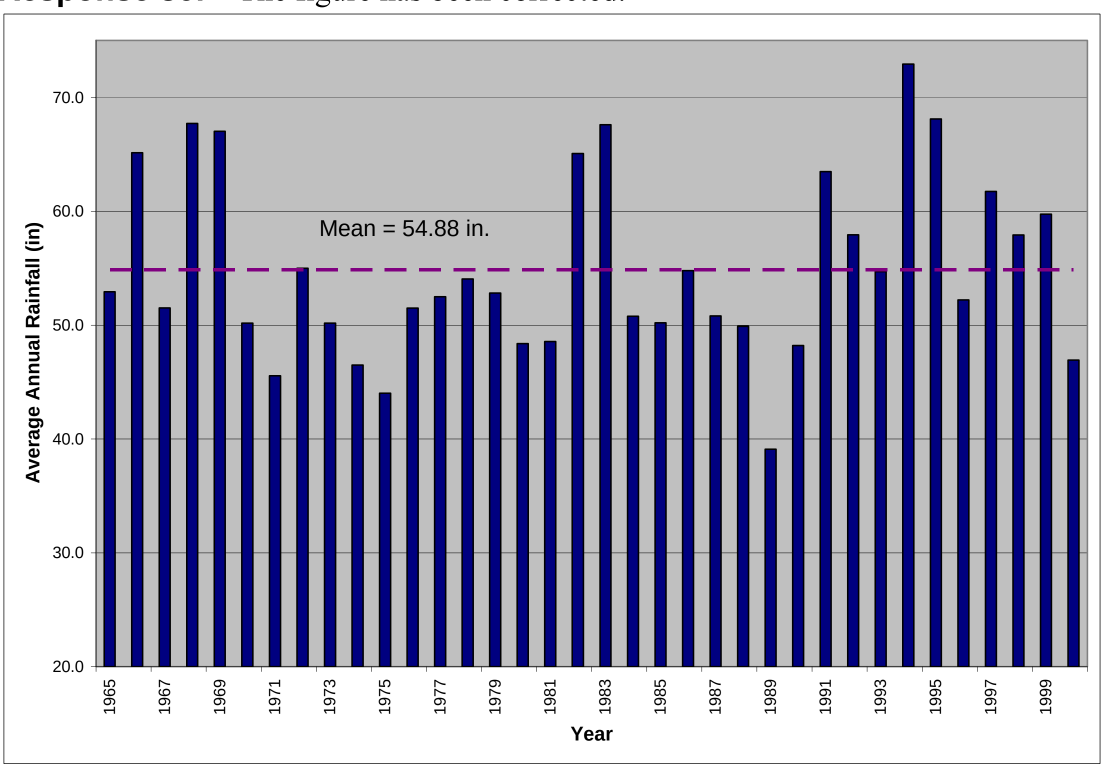


Figure : Average Annual Rainfall (in) from 1965 -2000.

Comment / Question 37: The "Mean = 5 in." line is drawn on the graph at about 4.75".

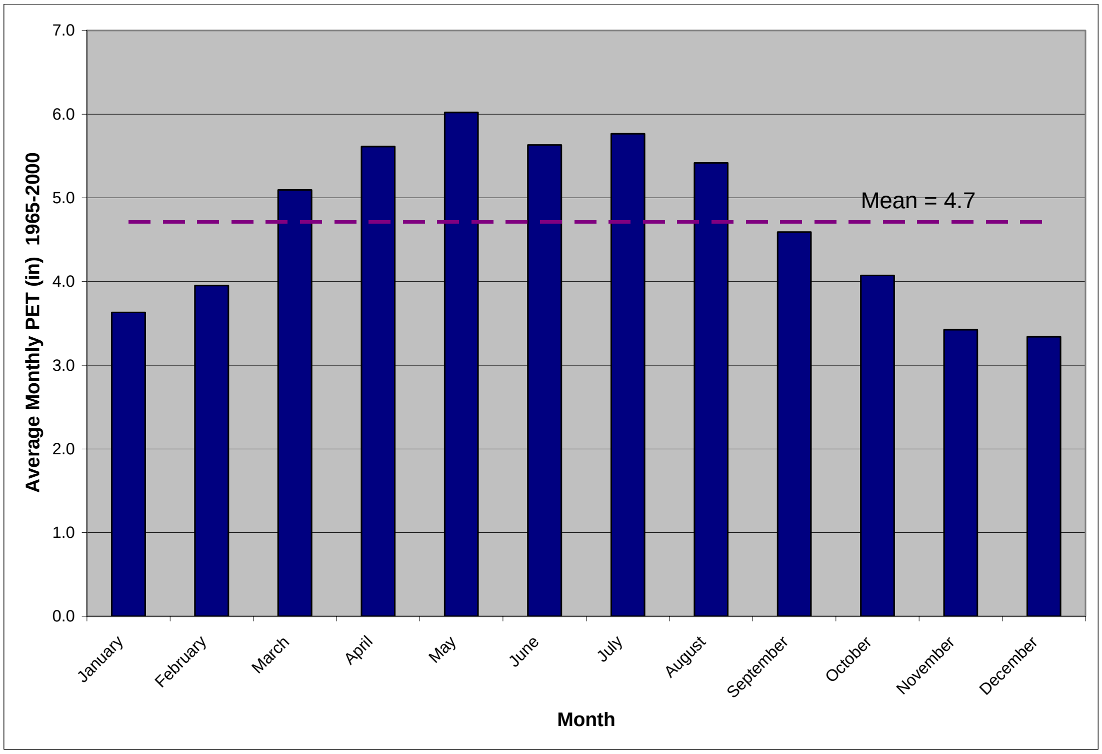


Figure: Average Annual Evapotranspiration (in) for Wet Marsh from 1965 -2000.

Response 37: The figure has been corrected.

Comment / Question 38: Table 2 land area percentages sum to 101%.

Response 38: The percentages have been corrected by adding one decimal place to the percent of land use.

Table 1. Percent of Total Area by Land Use Types in the Study Area.

Land Use Type	Acres	Percent
Wetlands	1608136	48.9
Water	68897	2.1
Urban and Built Up	618578	18.8
Transportation and Communications	82296	2.5
Barren Land	22132	0.7
Sugar Cane	429486	13.1
Agriculture Crops	91811	2.8
Other Agriculture	96416	2.9
Improved Pasture	38225	1.2
Unimproved Pasture	22718	0.7

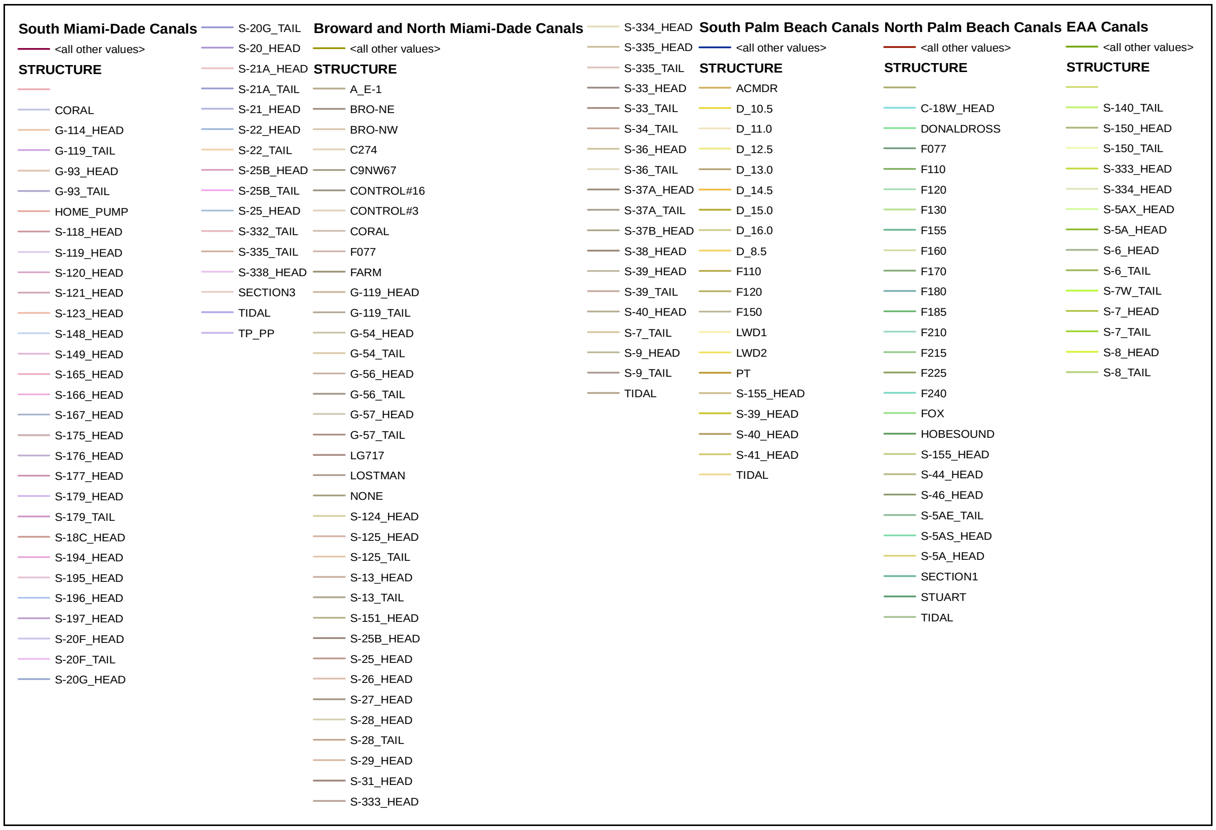
Upland Non-Forested	8475	0.3
Upland Forest	198490	6.0

Comment / Question 39: Please provide examples of secondary canals being used to maintain quantity and quality of runoff at predevelopment levels. Unless this only refers to storm runoff events, it would seem to be difficult to achieve those quantities and qualities.

Response 39: Some examples of secondary canals (e.g., Lake Worth Drainage District canals) will be provided. The purpose of this statement is to define secondary canals. The LECsR Model is not a water quality model.

Comment / Question 40: Provide a color legend. One cannot now distinguish between Primary, Secondary, and Tertiary canals. Numbering the different canal systems as they are used in the model should also be provided somewhere in a figure in the report.

Response 40: A legend for Figure 12 is provided below. The purpose of this figure is to show the great spatial variation in control levels over the study area. The different colors in the figure do not differentiate primary, secondary, or tertiary canals from one another; the colors represent various control levels. In Chapter 3, Figures 63 to 67 show the canal systems as modeled in the River Package (Rivers, Streams), Drain Package (Drains), Diversion and Wetland Packages (Flows). The Culverts are not modeled and Figures 63 to 67 will be modified and the culverts will be removed.



Comment / Question 41: Please indicate whether these Canals are Primary, Secondary or Tertiary in the figure title or by using different colors.

Response 41: Please refer to Response 40.

Comment / Question 42: The Hawthorn Group may have an extremely low permeability, but it is not "impermeable".

Response 42: In the study area, the Hawthorn Group is non-water-yielding. In areas outside the study area, the Hawthorn Group becomes water-yielding and is called the Intermediate Aquifer System.

Comment / Question 43: If the Gray limestone aquifer is confined anywhere, rather than semiconfined, please show it

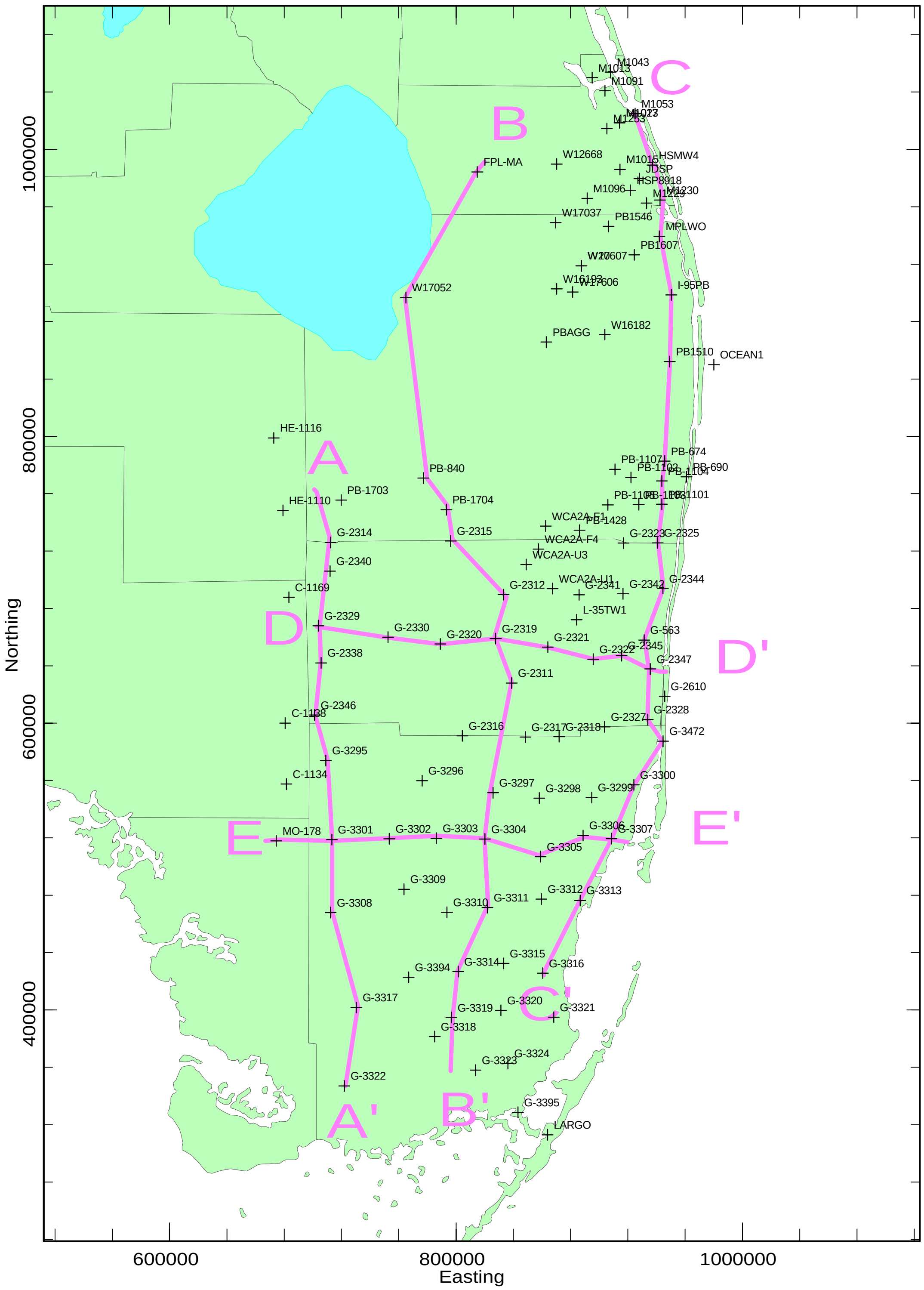
Response 43: The Gray Limestone aquifer is not confined anywhere in the study area.

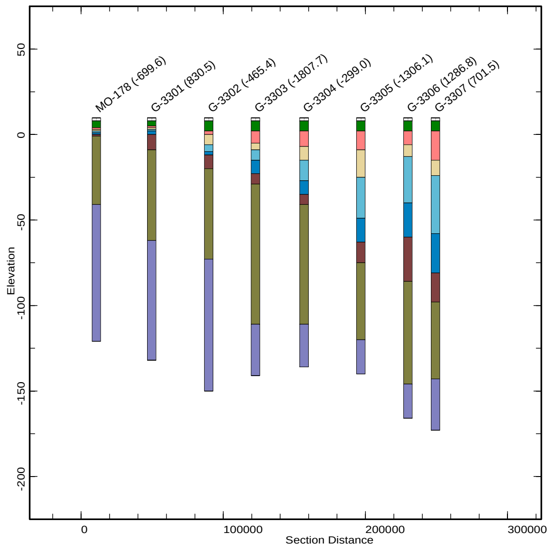
Comment / Question 44: Here and other places, please correct the figure numbers being referred to.

Response 44: The figure numbers have been corrected.

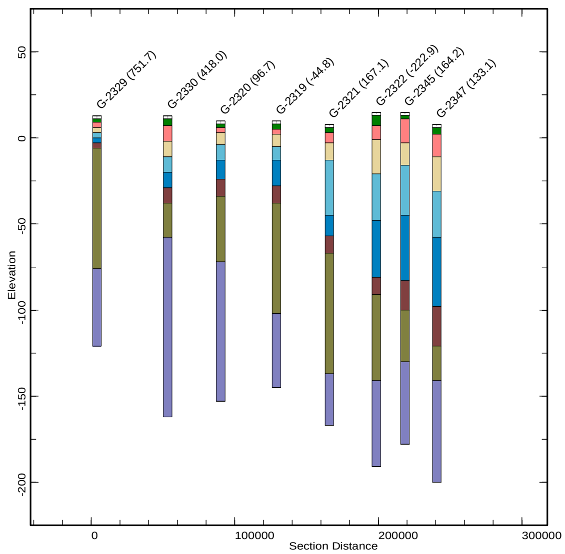
Comment / Question 45: There is no common vertical scale to facilitate comparison of the cross-sections. For example, Figure 19 vertical scale is +90' to -182' while Figure 20 vertical scale is +105' to -300'.

Response 45: New figures have been created by applying a common vertical scale and will be added to the documentation.

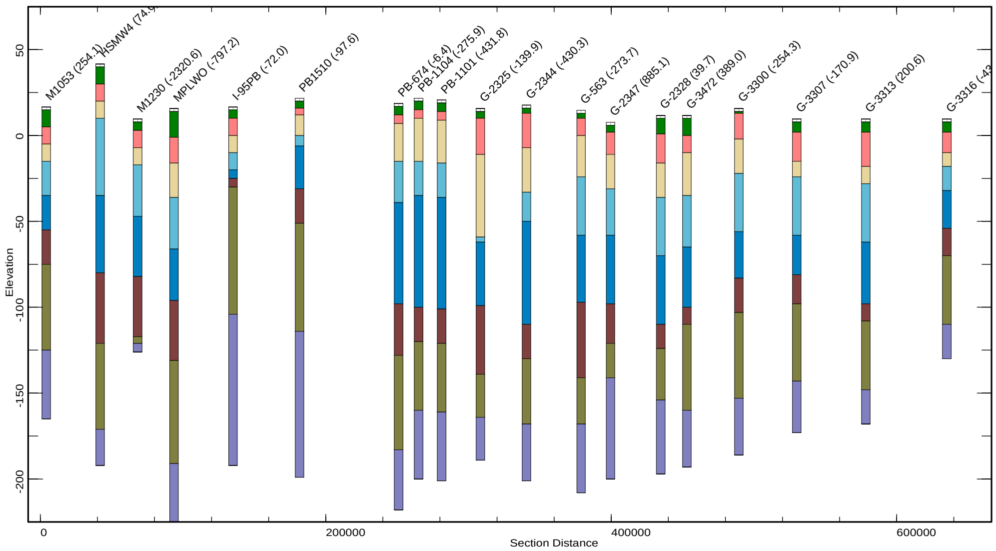

A
A'
B
B'
C
C'
D
D'
E
E'
M1043
M1013
M1091
M1053
HSMW4
JDSP
M1230
MPLWO
PB1607
I-95PB
PB1546
W12668
M1096
W17037
FPL-MA
W17052
W16182
PBAGG
PB1510
OCEAN1
HE-1116
HE-1110
PB-1703
PB-840
PB-1704
PB-674
PB-690
PB-1428
WCA2A-F4
WCA2A-U3
G-2314
G-2315
G-2323
G-2325
G-2340
C-1169
G-2312
G-2344
L-35TW1
G-2329
G-2330
G-2320
G-2319
G-2321
G-563
G-2345
G-2347
G-2338
G-2311
G-2610
G-2328
G-2346
G-2316
G-2327
G-3472
G-3295
C-1134
G-3296
G-3297
G-3298
G-3300
MO-178
G-3301
G-3302
G-3303
G-3304
G-3305
G-3307
G-3309
G-3308
G-3310
G-3311
G-3312
G-3313
G-3315
G-3394
G-3314
G-3316
G-3317
G-3319
G-3320
G-3321
G-3318
G-3324
G-3322
G-3395
LARGO
1000000
800000
600000
400000
Northing
600000
800000
1000000
Easting

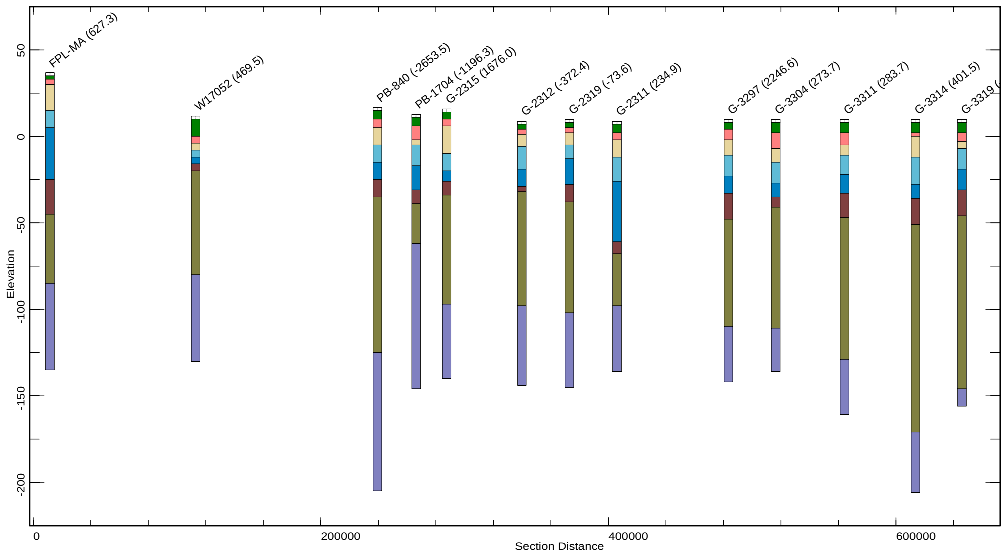


Vertical Exaggeration 1: 1200

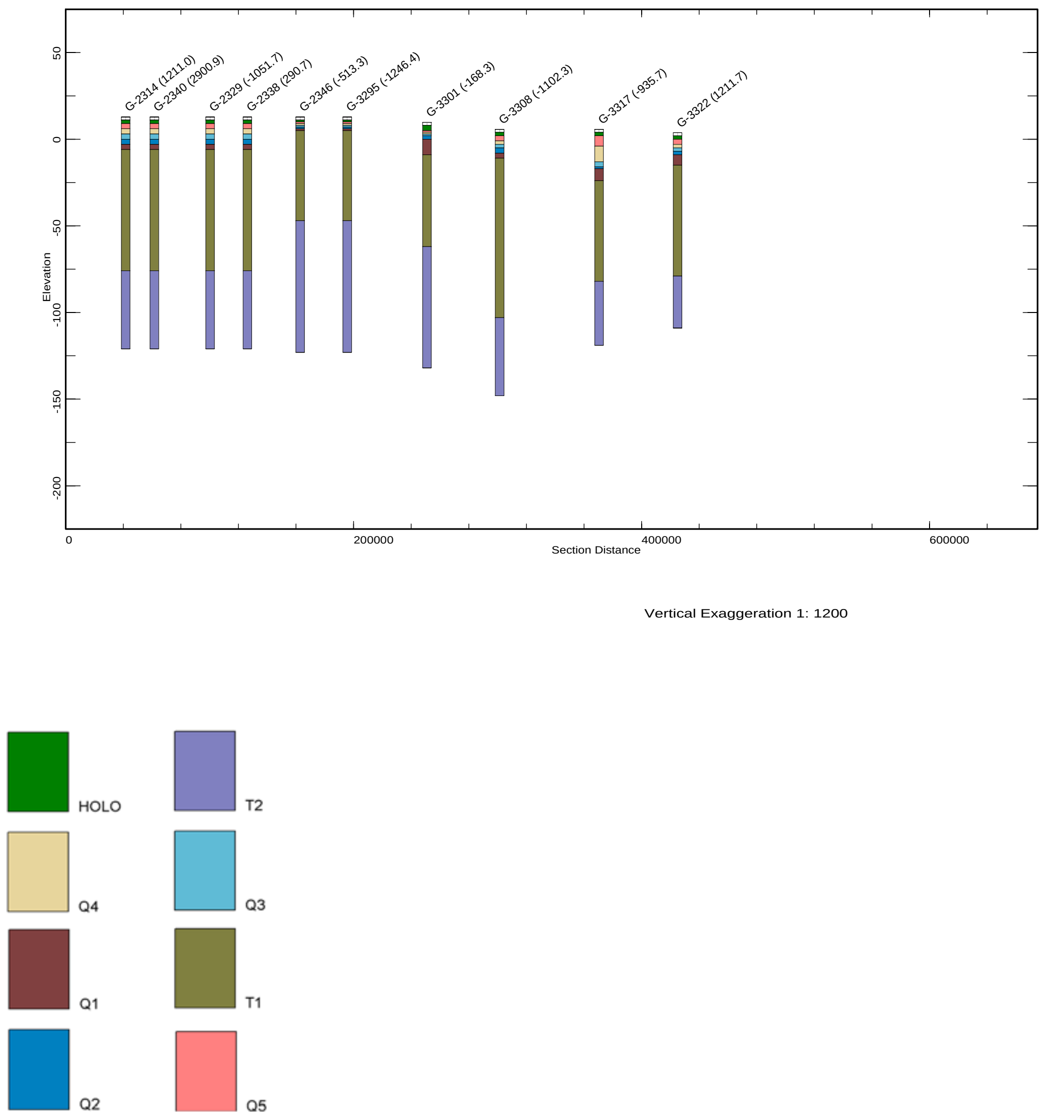


Vertical Exaggeration 1: 1200


M1053 (254.1)
HSMW4 (74.9
M1230 (-2320.6)
MPLWO (-797.2)
I-95PB (-72.0)
PB1510 (-97.6)
PB-674 (-6.4)
PB-1104 (-275.9)
PB-1101 (-431.8)
G-2325 (-139.9)
G-2344 (-430.3)
G-563 (-273.7)
G-2347 (885.1)
G-2328 (39.7)
G-3472 (389.0)
G-3300 (-254.3)
G-3307 (-170.9)
G-3313 (200.6)
G-3316 (-43
50
0
-50
-100
-150
-200
Elevation
0
200000
400000
600000
Section Distance



Vertical Exaggeration 1: 1200



Comment / Question 46: Some important APT tests are obscured by other symbols in southern Dade County.

Response 46: We will try adjusting or re-scaling the symbols on the map, but we may need to create another map and zoom into southern Dade County.

Comment / Question 47: Need to specify units of T in this equation.

Response 47: Units of T are ft^2/day. Units of Q were changed to ft^3/day.

Comment / Question 48: The referenced Figure 26 is labeled Fig 36 on page 64.

Response 48: The figure numbering will be corrected.

Comment / Question 49: Table formatting errors. Footnote or reference "a" at the bottom of the table is not referenced anywhere in the table.

Response 49: The table has been updated.

Table3. Minimum Canal Operational Levels (ft NGVD) for the Biscayne Aquifer.

Canal/Structure	Wet Season Control Level	Average Canal Level	Drought Management Control Level	Minimum Canal Operational Levels to Avoid Violation[a]
C-51/S-155	8.50	8.12	7.80	7.80
C-16/S-41	8.20	8.23	7.80	7.80
C-15/S-40	8.20	8.39	7.80	7.80
Hillsboro/G-56	7.70	7.43	6.75	6.75
C-14/S-37	7.20	6.82	6.50	6.50
C-13/S-36	5.60	4.43	4.00[b]	3.80
NNR/G-54	4.00	3.68	3.50	3.50
C-9/S-29	3.00	2.16	1.80	2.00
C-6/S-26	4.40	2.55	2.50[b]	2.00
C-4/S-25B	4.40	2.55	2.50[b]	2.20
C-2/S-22	3.50	2.86	2.50[b]	2.20

1. a. Minimum Canal Operational Levels needed to protect against MFL violations during drought conditions. Water levels within the above canals may fall below the proposed minimum canal level for a period of no more than 180 days per year.
2. b. These levels will be maintained if sufficient water is available.

Comment / Question 50: Table is incorrectly formatted. Some data cannot be read.

Response 50: The table has been corrected. Please see Response 49.

Comment / Question 51: Figures 38 through 41 are not referenced in the text.

Response 51: References to these figures will be added.

Comment / Question 52: This figure could be enhanced by including the proportions of groundwater versus surface water use of each county.

Response 52: This comment will be seriously considered.

Comment / Question 53: Figure 39 appears to have 2 captions (one for Figure 39 and one for Figure 40).

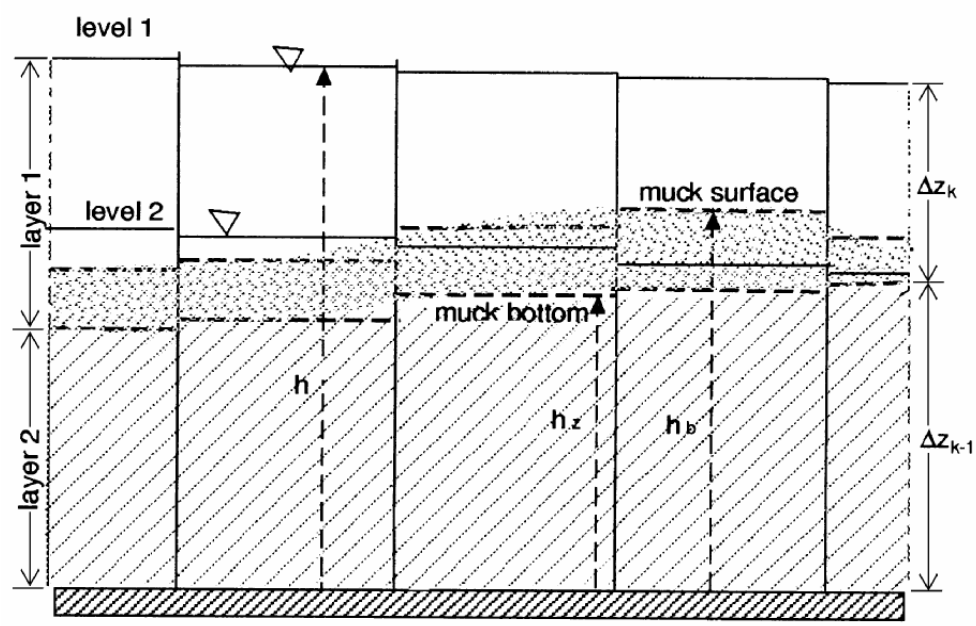
Response 53: The figure will be corrected.

Chapter 3

Comment / Question 54: Are all layer one cells enabled in the Wetland Package? There are variables in Figure 43 that are not explained in the text (e.g., hz, hb, zk, etc.). How was the WTL Package validated? How sensitive is it to the selection of a and b? Are a and b calibration parameters? What do alpha and Beta refer to? How were they selected? How are they distributed?

Response 54: This section, Add-on Packages describes the computer code. The model design for the Wetland Package is discussed in the second part of Chapter 3 and shown in Figure 62. No, not all of the cells in layer one are enabled in the Wetland Package, but they could be. The Wetland Package defines the active model cells that will be simulated as wetlands (ibnd_wtl) just as the active groundwater cells are defined in the Basic Package. The user must select the areas considered as wetlands.

Explanations of the variables are provided for the following figure.



H is the water table elevation in layer one (level 1) when there is ponded water in all wetland cells. The level 2 water table elevation illustrates a drier hydropattern when the water table falls below land surface in some of the wetland cells, but remains ponded in other wetland cells. H_z is the bottom elevation of layer one. H_b is the top elevation of the muck or peat. ΔZ_k is the saturated thickness of layer one, including the ponded water. ΔZ_{k-1} is the thickness of layer 2 – layer underlying the wetlands.

The Wetland Package was evaluated by comparing a solution of the diffusion equation from MODFLOW with a solution of the diffusion equation from the IMSL Fortan Library (Restrepo *et al.* 1998). The test-case example has an axisymmetric solution when the system has a sinusoidal water surface profile and a flat bottom. Initial conditions were provided by a bell-shaped mound. The numerical solution in MODFLOW matched closely with the solution generated by the IMSL which is highly verified. The Wetland Package has been applied to many wetland systems in the SFWMD for many projects. The Wetland Package has been used by the SFWMD for the past eight years with much success.

The exponents, alpha (a) and beta (b) are defined in Chapter 3, pages 74-75. Alpha is the power of the gradient and beta is the power of the ponding depth. As discussed by Restrepo *et al.* (1998), the sensitivity of beta indicates that the overland flow wave propagates faster as the beta coefficient increases. In wetland systems the surface water gradient is small; therefore, the exponent, alpha is not very sensitive to changes and a value of 1.0 can be assumed (Restrepo *et al.* 1998). In the LECsR Model, the sensitivity of alpha was not tested due to the previous statement. The beta exponent was tested for sensitivity in the LECsR Model. Neither the alpha nor the beta are considered calibration parameters. The value for beta in the LECsR Model is 3. Kadlec (1990) recommends using a beta between 2 and 4. The sensitivity for LECsR applied the recommended Kadlec range of 2 and 4. A value of 4 started creating instabilities. A value of 2 resulted in the solution getting closer to darcian flow. The alpha and beta exponents were selected for the LECsR model based on the Kadlec recommended values, the sensitivity analysis of the exponents, and the SFWMD's experience with the Kadlec equation in previous modeling efforts. The alpha and beta are specified as constant values (in time and space) in the Wetland Package.

Comment / Question 55: How deep is the water in the wetlands generally? How do head errors on the order of 1 ft affect the utility of this package? Has this sensitivity been assessed?

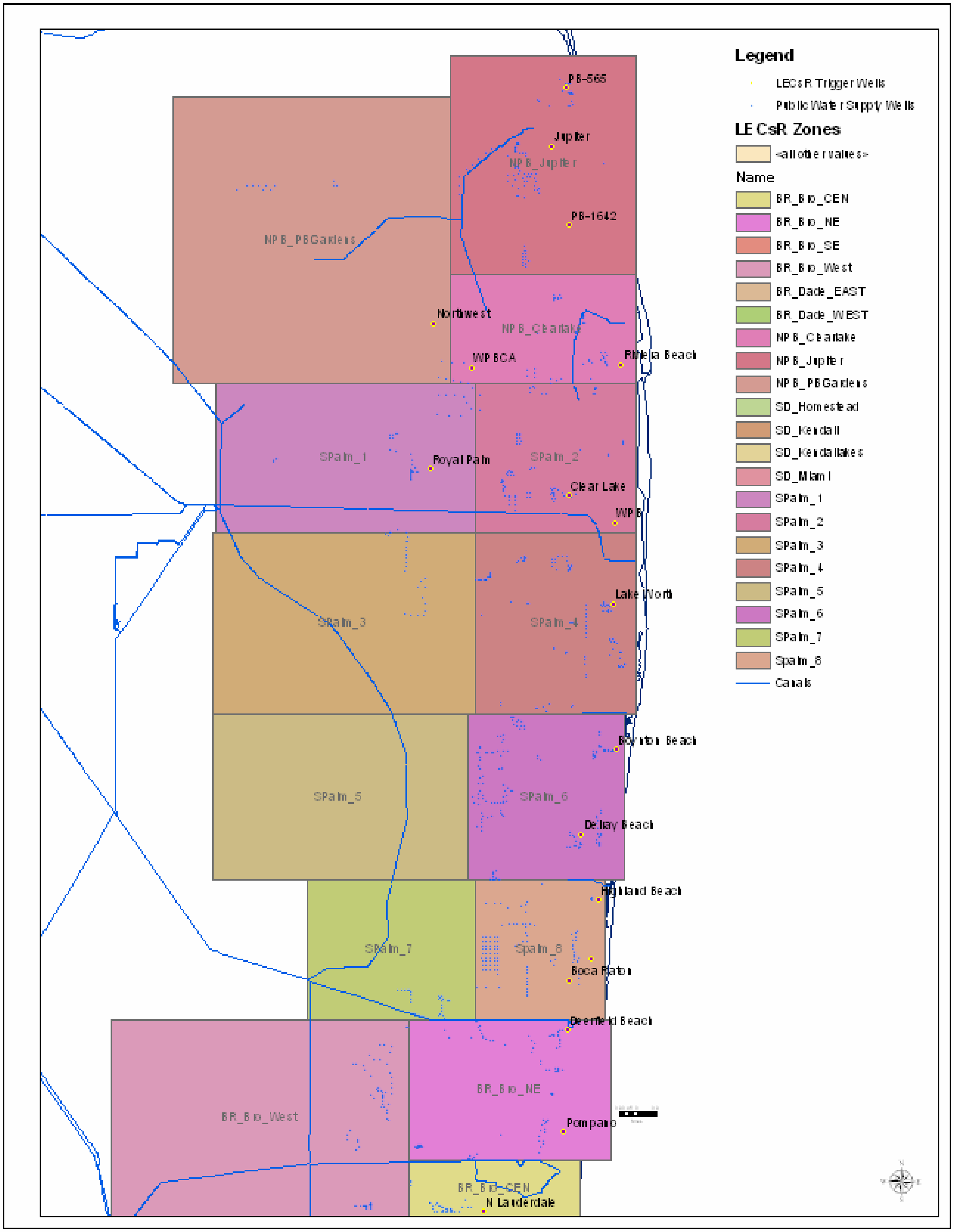
Response 55: Generally, the ponded water is 1 ft to 3 ft deep, but in some cases can be up to 6 ft deep in the wetlands, especially in wetland that were compartmentalized. The calibration graphics (Appendix A) show that in most cases the simulated surface water stages located in wetlands have head errors less than 0.5 ft. Sensitivity analyses (see Chapter 4) have been done for most of the wetland parameters.

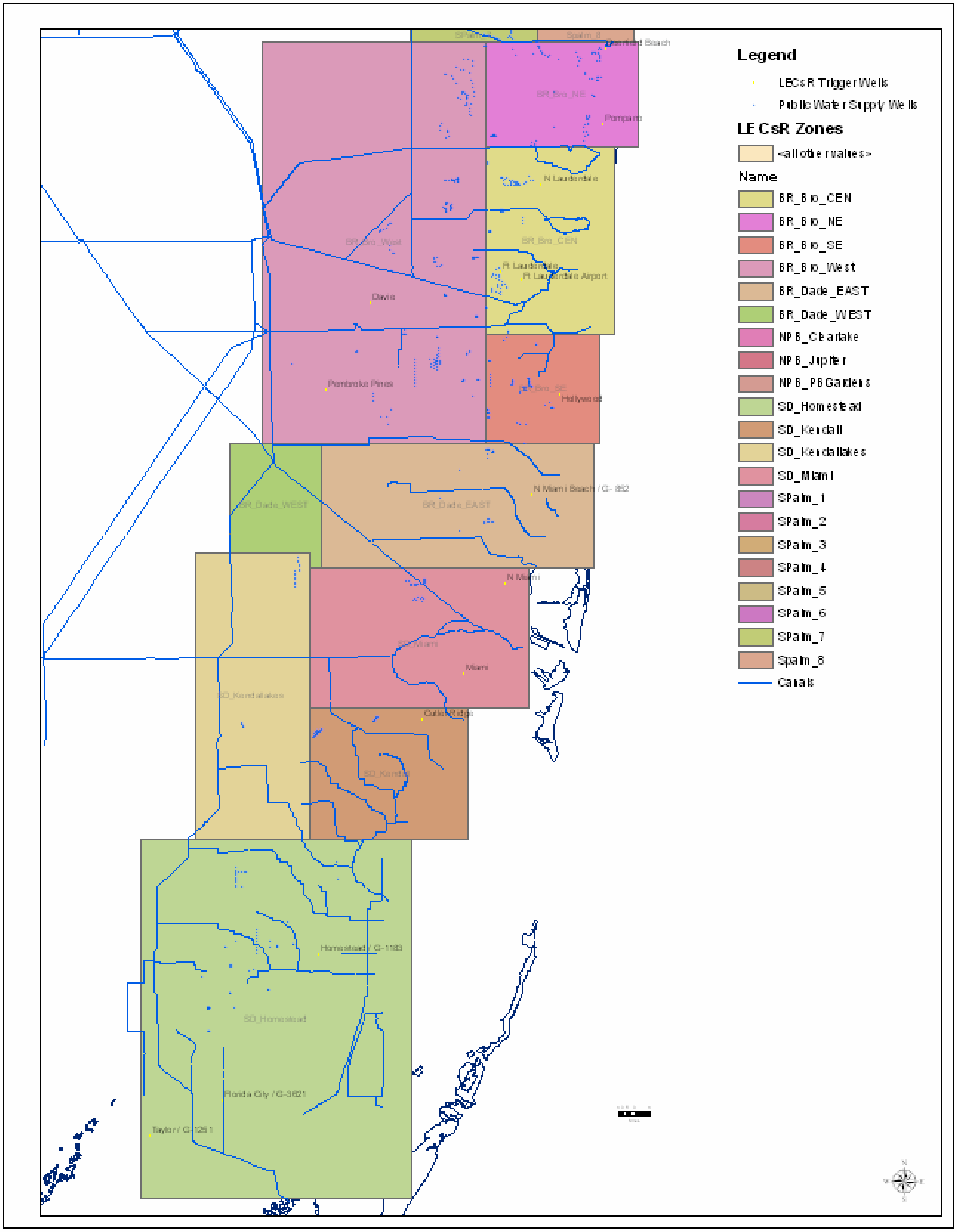
Comment / Question 56: The text states that "[f]lows can be routed from upstream to downstream basins." In the case of the Diversion Package does the definition of "routed" simply mean that water can be moved instantaneously through the grid, or does it mean that water is actually routed in the transient hydraulic flow sense through the grid?

Response 56: The Diversion Package moves water instantaneously through the grid; however, the water applied from the Diversion Package to the Wetland Package cells is routed "in the transient hydraulic flow sense" by the Wetland Package.

Comment / Question 57: How are reduced pumping rates determined when the Trigger Package is invoked? Does the model iterate to find the maximum pumping rate that just eliminates the violation? In Trigger package, please explain why, if a violation occurs, the previous stress period's pumpage used instead of some new converged value? How are individual well pumping rates determined when the Trigger Package is invoked due to multiple production wells causing the violation?

Response 57: The Trigger Package is not used in the calibrated model; it is used only for predictive applications. The trigger module works according to zones, which are user-specified rectangles. In each zone there are trigger cells. If the head (or drawdown) in a trigger cell at the end of a stress period is lower than a standard, which is user-specified, the program looks for each well in the zone and reduces the pumpage for the next stress period by a fraction specified in the input data. No, the model does not iterate to find the maximum pumping rate therefore the previous pumpage value must be used to calculate the reduction in pumpage. The individual well pumping rates are determined by the zones and pre-specified trigger levels as discussed above and in Chapter 3, pages 79-80. The following figure shows the trigger zones and the trigger wells.


Legend
LECsR Trigger Wells
Public Water Supply Wells
LECsR Zones
<all other values>
Name
BR_Bro_CEN
BR_Bro_NE
BR_Bro_SE
BR_Bro_West
BR_Dade_EAST
BR_Dade_WEST
NPB_Clearlake
NPB_Jupiter
NPB_PBGardens
SD_Homestead
SD_Kendall
SD_Kendallakes
SD_Miami
SPalm_1
SPalm_2
SPalm_3
SPalm_4
SPalm_5
SPalm_6
SPalm_7
Spalm_8
Canals
PB-565
Jupiter
NPB_Jupiter
PB-1642
NPB_PBGardens
Northwest
NPB_Clearlake
WPBCA
Riviera Beach
SPalm_1
Royal Palm
SPalm_2
Clear Lake
WPB
SPalm_3
SPalm_4
Lake Worth
Boynton Beach
SPalm_5
SPalm_6
Delray Beach
Highland Beach
SPalm_7
Spalm_8
Boca Raton
Deerfield Beach
BR_Bro_NE
BR_Bro_West
Pompano
BR_Bro_CEN
N Lauderdale


Legend
LECsR Trigger Wells
Public Water Supply Wells
LECsR Zones
<all other values>
Name
BR_Bro_CEN
BR_Bro_NE
BR_Bro_SE
BR_Bro_West
BR_Dade_EAST
BR_Dade_WEST
NPB_Clearlake
NPB_Jupiter
NPB_PBGardens
SD_Homestead
SD_Kendall
SD_Kendallakes
SD_Miami
SPalm_1
SPalm_2
SPalm_3
SPalm_4
SPalm_5
SPalm_6
SPalm_7
Spalm_8
Canals
N Lauderdale
Ft Lauderdale
Ft Lauderdale Airport
Davie
Pembroke Pines
Hollywood
N Miami Beach / G- 852
N Miami
Miami
Cutler Ridge
Homestead / G-1183
Florida City / G-3621
Taylor / G-1251
Pompano

Comment / Question 58: If the UGEN (utility generation) package generates new input flow rates on the fly, is some iteration occurring and coordinated with MODFLOW flow simulation iterations to cause convergence within a stress period? A related question is what is the time delay between noticing a condition and implementing a change in management?

Response 58: The UGEN Package is a utility package that was created to save time during model execution and space when setting up MODFLOW package data. This package is not part of the groundwater flow equation; there is no iteration process.

Comment / Question 59: Output Control: The monthly summation of flows seems to imply that SFWMD doesn't look at these on a daily basis? Is there no calibration to canal flows, diversions, etc where this is necessary?

Response 59: Typically, the Output Summation Enhancement, which sums the daily flows to monthly flows, is used for the LECsR Model due to the output of large files (i.e., greater than 10 GB for the 15-year calibration run). MAS has calibrated to daily structure flows in the northern Palm Beach County area only.

Comment / Question 60: Were the benefits of a variable spacing grid considered? Is there a way to accommodate the SFWMM model comparison to the LECsR model and still take advantage of larger cell dimensions to the west and a more refined grid to the east where there are greater changes in heads over much shorter distances? The rationale for maintaining a uniform grid to interface with the SFWMM seems somewhat less important than building a new model that is optimized to address the system dynamics.

Response 60: The benefits were not considered due to the impact on time required to pre- and post-process model data. It was decided that the resolution of 704 ft by 704 ft is adequate for a subregional model in the urbanized areas.

Comment / Question 61: Inverse distance weighting seems to be a rather crude approach to creating the model layer surface elevations given the recent advances in geostatistics, Gaussian simulation, and solid earth modeling. Were other interpolation methodologies evaluated and/or tested to determine if more representative layer surfaces could be produced? The geologic/stratigraphic control data appear to be sufficient to construct a solid earth model of the SAS. Such an investment would serve multiple purposes ranging from visualization of the model domain in 3D to providing the most accurate geometry of the geologic units upon which to base the model structure.

Response 61: Please refer to Response 28. The software, Viewlog was used to view the model layers in 3D.

Comment / Question 62: Why wasn't the ground surface elevation established first with a high level of accuracy and then all the logs "hung" from it to produce layer elevations that did not have to be artificially adjusted?

Response 62: The ground surface elevations from the geologic control wells originated from surveys, so the elevations should be accurate at those points.

Comment / Question 63: It appears that the layer 1 thickness was artificially deepened to avoid drying of cells. This adjustment undermines the geological basis of the layering scheme and propagates the stratigraphic "error" downward through the model. How are these seemingly conflicting approaches to model layer development (i.e., stratigraphic basis vs. avoidance of cell drying) reconciled?

Response 63: Please refer to the figures from Response 118. The most dramatic changes were made to small areas in the north and western model domain where the hydraulic conductivities are relatively low and similar to one another.

Comment / Question 64: How is the pinching out of the lower permeability unit in Layer 2 to the east handled in the model? Is there an abrupt change in K and/or does the layer thin in this area, or both?

Response 64: The lower permeability unit is included in layer 3. The paragraph was re-written as, “Layer 2 is set to “confined/unconfined” in the BCF package and represents the more productive units of the SAS and the Biscayne aquifer within the study area. This layer extends from about -10 feet to -142 feet NGVD. The bottom of this layer resides in the Biscayne aquifer.

Comment / Question 65: Was there any attempt to verify that the "bulls eyes" seen throughout the plots of layer thickness are real versus an artifact of the inverse distance weighting interpolation scheme?

Response 65: The thickness maps were revised and placed on Web board. There are still some bulls eyes due to IDW.

Comment / Question 66: Hydraulic conductivities on the order of 75,000 ft/day seem only realistic for perhaps cavernous limestones which is not the case within the study area. Does the SFWMD believe that such ultra-high hydraulic conductivity values are representative of actual aquifer conditions within the SAS? Heath, 1983, Basic Ground-Water Hydrology, pg. 13 suggests that 10,000 ft/day is an absolute upper bound on K in carbonate rocks.

Response 66: The reported high hydraulic conductivity values reported from south Miami Dade County were obtained from specific capacity tests conducting in the area. Production wells in this area may be penetrating the Key Largo Formation which is a series of Quaternary marine reef systems which tend to be extremely productive. These tests may be over predicting the hk values in this area because drawdowns are barely measurable. Sensitivity analysis for this region indicates that calibration of the monitor wells in the region should not be adversely impacted if the hk was lowered. We will investigate lowering the hk in the area to the 25,000 ft/day to 50,000 ft/day range to be consistent with other tests conducted in the area.

Comment / Question 67: The 70 to 75000 ft/d hydraulic conductivity zone in Dade County seems to be a rather abrupt change, going from in some cases 25000 ft/d to 75000. Although the tests this is based upon include 3 APTs, is it reasonable? Is the K determination based primarily on the APTs or specific capacity tests? Are you confident that the K can be extrapolated across the entire model layer?

Response 67: The values are consistent with the literature for the area, and the rocks are karstic, with the water moving through preferential flow paths rather than matrix permeability. In the absence of the actual head difference data, the following is a range of possibilities for a range of possible head differences:

k = n l^2 / ht : from Todd's Groundwater Hydrology

travel time	l	n	H	K
0.258	328	0.04	1	16680
0.258	328	0.04	2	8340
0.258	328	0.04	3	5560
0.258	328	0.04	4	4170
0.258	328	0.04	5	3336
0.258	328	0.2	1	83398
0.258	328	0.2	2	41699
0.258	328	0.2	3	27799
0.258	328	0.2	4	20850
0.258	328	0.2	5	16680

l = distance between the injection and recovery well

ı= porosity

H = head difference between injection and recovery well

: = estimated hydraulic conductivity

\ll units are feet & days

Head differences of 1 – 5 feet are based on our experiences with APT's in the Broward county, where we pumped the Biscayne at 3,000 gpm and got less than 1/10 of a foot of drawdown at monitor wells 100 feet away. The 'monitor' well in the tracer test was 328 feet away, with a pumping rate of 7,900 gpm, so the H values given should be conservative. The USGS estimated a porosity around 4% at the site, which is significantly lower than any literature value previously seen for the Biscayne, we have provided K estimates based both on that value, and a more typical value of around 20%. If porosities are in the 20% range, the K values used in the LECsR are probably are realistic. If they are drastically lower, then the model values are too high.

Our experience in Broward points out a problem with many APT's run in the area we couldn't get enough drawdown from the monitor well to do curve matching analysis.

Comment / Question 68: What causes the circular patterns of hydraulic conductivity shown in the figure? Are they based on actual data or artifacts of the interpolation methodology?

Response 68: They are artifacts of the interpolation methodology.

Comment / Question 69: Why is the anisotropy set at 0.05 throughout the model domain if it is intended to represent just the Biscayne aquifer? If an anisotropy ratio of 0.5 to 0.1 was reasonable from other studies, why isn't this smaller difference used in the model for layers not representing the Biscayne aquifer?

Response 69: A constant value was chosen and the model is not sensitive to Vcont.

Comment / Question 70: Please clarify. I infer that the base elevation of all Layer 1 cells is 0 NGVD. This disagrees with what is implied in p75, Fig 43. Also, it seems like it would be difficult to accurately predict ponded water depth if Layer 1 parameters are a combination of all materials above 0 NGVD.

Response 70: The bottom of layer 1 is not a constant 0 ft, NGVD. Values were lowered only when values were greater than 0 ft, NGVD.

Comment / Question 71: To address drying-rewetting problems, please explain why it would not be better to change the code to cause some Layer 1 minimum saturated thickness or minimum transmissivity rather than to set 0 NGVD as a bottom elevation of all wetland cells in layer 1.

Response 71: Please refer to Response 70.

Comment / Question 72: Please clarify how the Levees are represented in the model, and their relationship to the wetlands. A close-up of the cells and boundaries should be shown.

Response 72: The levee top elevations overwrite the topographic cell values. The levee elevations will bound the wetlands, but the levees still allow seepage interaction.

Comment / Question 73: The use of the drain and river packages assumes a potentially infinite source/sink term. How is flow tracked to and from these boundaries to assure that the flows are reasonable? I am referring to global, local, and temporal domains.

Response 73: MAS is aware of this potential problem. It is further complicated by lacking data. The northern Palm Beach County model domain has been calibrated for both heads and flows through structures. These flow budgets, which include seepage rates, are checked using the MULTIBUD program which shows the flow over time. MAS agrees that we should continue this process of checking canal seepage rates for the rest of the model domain.

Comment / Question 74: The use of the river package implies that canal stages are pre-set (not calculated). How are these specified, particularly with time? I would have thought that canal stage is a function of precipitation (in addition to operational controls) and hence groundwater head dependent. Maybe getting ahead of myself, but how will they be set for predictions?

Response 74: During model development, stages for the River and Drain Packages are assigned using daily, historical data from the SFWMD's hydrologic data base, DBHydro or permit information (e.g., stages for flood control, maintenance levels for wet and dry seasons). Spatially, the same stage is assigned to a canal reach according to the headwater (and less often, tailwater) elevation(s).

Both the LECsR Model and the SFWMM uses the same 36-yr (i.e., 1965-2000) climatic conditions and Public Water Supply Well withdrawals for predictive applications. The SFWMM is primarily a surface water model where canal stages change in response to operations and precipitation. The SFWMM makes operational changes to the primary WMD canals and some secondary canals for a particular scenario. Canal stages from the regional model, SFWMM, for those canals which change on a daily basis for predictive scenarios are provided to the subregional model, LECsR.

Comment / Question 75: How are streams represented? Please show which cells use which packages (rivers, drains, flows, culverts, streams, etc.).

Response 75: Please refer to Response 92.

Comment / Question 76: The scaling factor (Eq. 5) appears to create unrealistically large vertical gradients per the layer head differences shown in Figure 69. Is this assessment correct and, if so, what are the implications for model accuracy near the tidal boundaries?

Response 76: Figure 69 does not show heads. This scaling factor reduces flows in the bottom aquifer layer. Please refer to example on page 119, paragraph 2.

Comment / Question 77: Please clarify how the topographic elevations were created, and assign a particular name to that set of values. For convenience and clarity, in the earlier section on data sources, you should assign a name to the particular set of values subsequently used for the topography in calibration. You should also explain precisely how the muck layer top and bottom elevations relate to the set of topographic elevations.

Response 77: This will be clarified in the final report. The muck layer top elevation corresponds to land surface elevations generated from the DEM.

Comment / Question 78: Please clarify what criteria were used to determine that the reported 3-simulation process of making 10 day transient simulations was adequate to reach steady-state conditions (as declared in sentence 2).

Response 78: Qualitative criteria were used. It was observed that the heads did not change significantly at the end of the 3-simulation process.

Comment / Question 79: Please indicate what day of the year is represented by the pseudo-steady heads developed as initial conditions for transient conditions, and justify its use

Response 79: January 1, 1986 was used since the model starts on an average day in the dry season.

Comment / Question 80: Please include flowcharts to show any differences in how ET and Recharge were handled during calibration versus how they should be handled during subsequent planning and management predictive simulations. If there are no differences, then management changes will not affect ET and recharge rates utilized by the model.

Response 80: The only difference in how ET and Recharge were handled during calibration versus how they should be handled during predictive simulations is that the land use is changed for the predictive simulations. A land use change may result in different ET and recharge rates due to changes in irrigated lands or pervious areas. The calculation procedure is the same. This procedure requires executing the ET-Recharge pre-processing program (Restrepo and Giddings 1994), which provides daily estimates of the potential ET and recharge rates. These rates are inputs to MODFLOW's ET and Recharge Packages.

Comment / Question 81: This says the recharge and ET time series are based on land cover and soil types. It does not mention site specific info such as depth of surface water or depth to water table. Further clarification is needed in this section to explain how each cell's recharge and ET are pre-determined.

Response 81: MAS will further clarify and revise this section. The ET and recharge rates that are pre-processed by the ET-Recharge Model (Restrepo and Giddings 1994) are applied to MODFLOW's ET and Recharge Packages in every active model cell. The ET-Recharge Model passes the ET deficit from the unsaturated zone (in areas that are not well-irrigated) to MODFLOW's ET Package, which computes the actual ET from the saturated zone as a function of depth to the water table and extinction depth.

Comment / Question 82: Please clarify whether ET and recharge are preprocessed and used as inputs only for the model Calibration. If this is also done during non-calibration predictive simulations it could be problematic. Please clarify how depth to water or depth of surface water is predetermined, and used to compute ET and recharge rates a priori for each cell.

Response 82: Please refer to Responses 80 and 81. Depth to water or depth of surface water is not pre-determined in the ET-Recharge Model ((Restrepo and Giddings 1994)). The ET-Recharge Model computes the unsaturated zone mass balance for a volume of control that depends on the crop type and growth stage of that crop.

Comment / Question 83: This states that the ET and recharge values developed before calibration were held relatively constant in the model throughout calibration. Please identify any situations in which they were changed, and why they were changed.

Response 83: The changes made to the ET and recharge rates are documented in Chapter 4, pages 139-140 and 163.

Comment / Question 84: In the calibration results, please explain sensitivity of calibration predicted heads to the process of predetermining Recharge and ET and not allowing them to be affected by temporally variable management decisions.

Response 84: Please refer to Chapter 4, page 190, which explains the sensitivity of the ET and recharge variables.

Comment / Question 85: Does holding the moisture content between land surface and the water table constant, which ignores the capillary fringe, suggest that there is less moisture available for ET or more moisture available for ET than is actually the case? What is the effect of this assumption on model performance?

Response 85: In wetlands the unsaturated zone was not taken into account in order to mode the full mass balance in MODFLOW. In wetlands, rainfall equals recharge and the extinctions depths are approximately 6 feet to allow MODFLOW to compute a value close to the potential ET, since the unsaturated zone is shallow. This paragraph needs to be re-worded and clarified in the final documentation.

Comment / Question 86: Does setting the ET to the supplemental crop demand systematically underestimate the actual ET?

Response 86: No, the actual ET will not be underestimated because in reality if the water is not available from precipitation or the saturated zone, the crop will become stressed and the actual ET will be lower than the potential ET. For a well-irrigated area the supplemental crop demand will be close to zero. In the case of the wetlands, the unsaturated zone is thin and the extinction depth is large enough to compute the actual ET close to the potential ET

Comment / Question 87: Please clarify. Some text indicates that unsaturated zone water is consumed by plants. Other text says that it is assumed that moisture content in the unsaturated zone does not change. Paragraph 3 implies that the MODFLOW ET package is employed. In a figure and/or table, please clearly indicate which cells use the MODFLOW ET package, and what parameters are used for that (extinction depth, etc.). In the same figure, please indicate which cells use the Restrepo package, etc.

Response 87: Please refer to Responses 80 to 86 and the following summary.

Model Package	Type of Data Required for Active Model Cells *indicates data generated by UGEN pkg during model execution **indicates data used in AFSIRS-based pre-processing program	Layer(s) Using Data for Estimating Input	Layer(s) Using Data As Direct Input
ET and Recharge			
(fort.15 and fort.18)	Rainfall data from gauges**	1	
	Rainfall data applied to Thiessen polygons**	1	
	Wet Marsh Crop Reference ET data**	1	
	Wet Marsh Crop Reference ET data applied to Thiessen polygons**	1	
	Land Use**	1	
	Overland flow/runoff and SCS curve numbers**	1	
	Florida soil series, textures, and available water capacity**	1	
	Crop water coefficients**	1	
	Topography	1	
	Irrigation efficiency**	1	
	Rooting depth**	1	
	Recharge rate		1
	ET extinction depth		1
	ET Surface Elevation		1
	Potential ET rate		1

Comment / Question 88: Could you comment on the potential error introduced spatially by splitting a total reported Q among multiple wells? Similarly, could you comment on the potential error of spreding a reported monthly pumping into equal daily increments? This seems like a limiting factor in grid spacing and temporal discretization. I'm interested in the potential effect on calibration.

Response 88: It's less important for small wellfields; it's more important for larger wellfields, which are spread out. The volume is correct on a monthly basis, but the daily temporal distribution may have errors. Also, the distribution of the individual wells is partially known based on utilities' determination of primary versus secondary wells. We would need daily pumping records which are not available during the calibration period. Currently, the B-List rules are in effect which require the permittee to meter individual pumping wells. Future modeling efforts will benefit greatly from this new data.

Comment / Question 89: As public water supply represents only 1/3 of the water use, there needs to be more than 4 sentences of discussion on non-public water supply.

Response 89: A more thorough discussion will be included in the final documentation.

Comment / Question 90: Code Selection: I agree with the selection, however, you should bring up that it is capable of representing the conceptual model. There might be questions as to why a more dynamic representation of surface water features, such as canals, was not used.

Response 90: A statement will be added to Chapter 3, Computer Code Selection Section, stating that MODFLOW with the SFWMD source code is capable of representing the conceptual model.

Comment / Question 91: Please clarify where Horizontal Flow Barrier package is used. Possibly it is never used for slurry walls in this study.

Response 91: The Horizontal Flow Barrier (HFB) Package was not used in the calibrated model. Table 5 presents the packages that are part of the SFWMD's source code. Since this section discusses computer code selection and the HFB Package could be activated in a simulation, this package is included. The HFB Package is sometimes used in predictive applications.

Comment / Question 92: Please state where cells that use the different packages are identified. Also summarize how many cells, pairs, or groups use each of the different packages.

Response 92: MAS will add a statement that indicates that the BCF, BAS, EVT and RCH Packages are applied to all active cells. The active WTL Package cells are illustrated in Figure 62. The GHB Package cells are shown in Figure 70. The active cells from the RIV, DRN and WEL Packages are now shown in figures. The RDF and DIV

Packages' source and sink areas have been shown conceptually in Figure 68, except for NPB. MAS will attempt to show these locations in the final documentation. Please refer to following table, which provides information on types of input data.

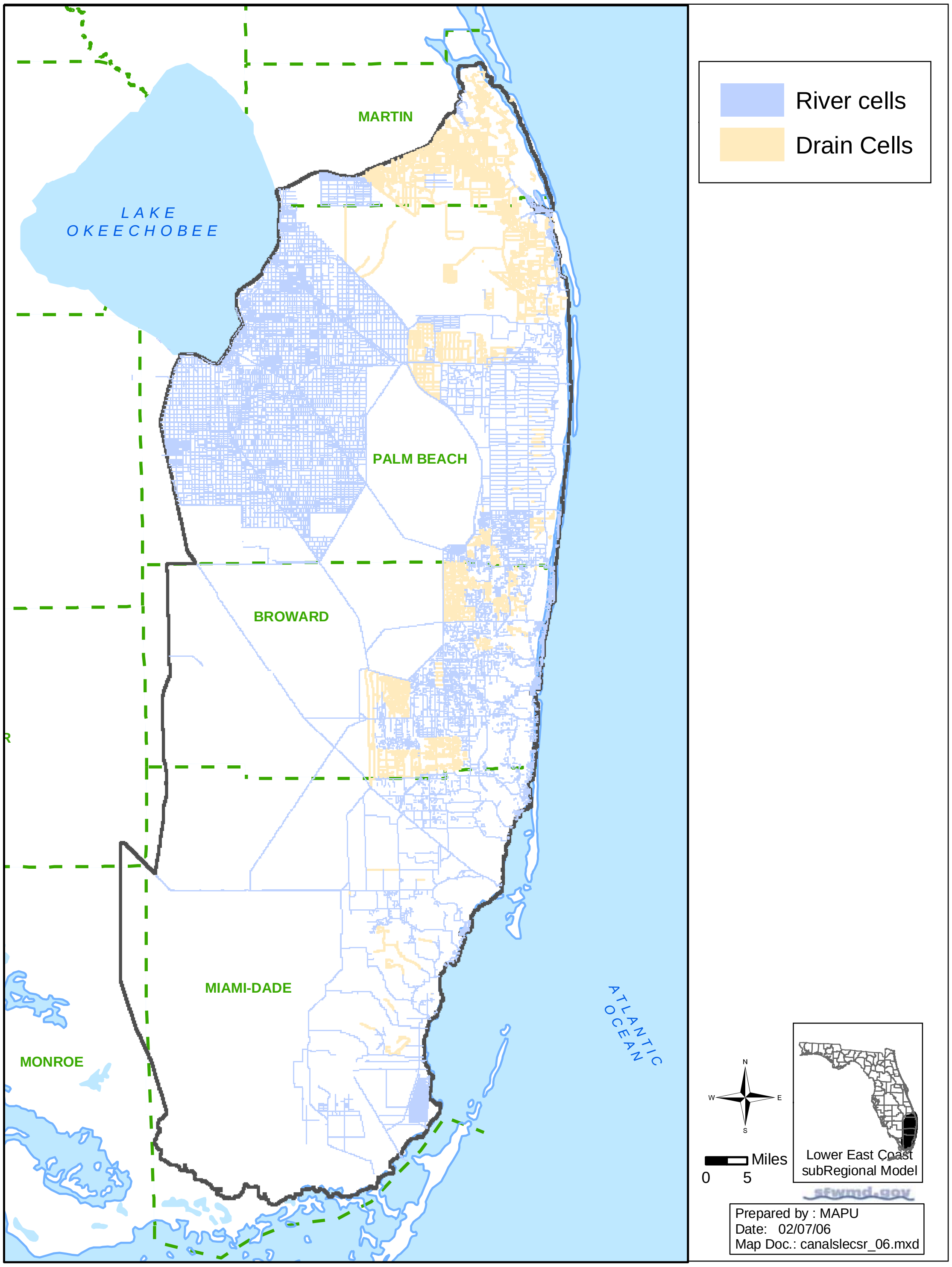
Model Package	Type of Data Required for Active Model Cells *indicates data generated by UGEN pkg during model execution **indicates data used in AFSIRS-based pre-processing program	Layer(s) Using Data for Estimating Input	Layer(s) Using Data As Direct Input
BAS			
(fort.1)	Active Model Boundary		1,2,3
	Intial Conditions		1,2,3
BCF			
(fort.11)	Horizontal Hydraulic Conductivity		1,2,3
	Vertical Anisotropical Factor	1-2, 2-3	
	Storage Coefficient		2,3
	Specific Yield		1
	Elevation of Aquifer Bottom		1,2
	Aquifer test data, lithologic descriptions	1,2,3	
	Vertical Conductance Coefficient	1-2, 2-3	
River			
(fort.14)	Streambed Elevation		1
	Streambed Conductance		1
	Streambed Sediment Thickness	1	

	River Stage*		1
	Canal profiles	1	
	Spatial coverage of canals		1
	Topography	1	
ET and Recharge			
(fort.15 and fort.18)	Rainfall data from gauges**	1	
	Rainfall data applied to Thiessen polygons**	1	
	Wet Marsh Crop Reference ET data**	1	
	Wet Marsh Crop Reference ET data applied to Thiessen polygons**	1	
	Land Use**	1	
	Overland flow/runoff and SCS curve numbers**	1	
	Florida soil series, textures, and available water capacity**	1	
	Crop water coefficients**	1	
	Topography	1	
	Irrigation efficiency**	1	
	Rooting depth**	1	
	Recharge rate		1

	ET extinction depth		1
	ET Surface Elevation		1
	Potential ET rate		1
Diversion			
(fort.29)	Locations of source and sink cells		1
	Lower and upper head limits at source cells		1
	Lower and upper head limits at sink cells		1
	Weir elevation (if applicable)		1
	Starting day of dry and wet season		1
	Daily flow diversion data*		1
Drain			
(fort.13)	Drain elevation		1
	Conductance between aquifer and drain		1
General Head Boundary			
(fort.17)	Head on the boundary*		1,2,3
	Hydraulic conductance between aquifer and GHB cell		1,2,3
	Tidal data, SFWMD stages, USGS TIME stages		1,2,3
	Initial heads	1	
	Equivalent freshwater head conversion*	1,2,3	
Reinjected Drainflow			

(fort.25)	Location of source and sink cells		1
	Conductance between aquifer and drain		1
	Upper head limits at source cells*		1
	Lower head limit at sink cells*		1
	Operational Schedules (if applicable)*		1
Trigger			
(fort.26)	Pumpage cutbacks by well type		1,2,3
	Trigger cell heads for different cutback phases		1,2,3
	Dry season and delay periods		1,2,3
	Trigger zones and trigger cells		1,2,3
	Historical Water Shortage Reports	1,2,3	
Multiple Wells			
(fort.12)	PWS Well discharge/recharge rates		1,2,3
	Well production zone depth (layer)	1,2,3	1,2,3
	Wellfield distributions	1,2,3	
	Allocations for non-PWS consumptive use permits	1,2,3	
	Trigger well use type (ie. Urban, ag, golf, etc.)		1,2,3
Wetlands			
(fort.24)	Active Wetland Boundary		1
	Land Use	1	
	Soil type	1	

	Muck horizontal hydraulic conductivity		1
	Muck anisotropy ratio		1
	Muck top elevation (topography)		1
	Anisotropic ratio in the model layer underlying the wetland		1
	Capillary fringe		1
	Kadlec conductance coefficients		1
	Specific yield of muck/peat and surface water body		1
	Kadlec alpha and beta		1
Other data			
	Water levels for observation network (1986 to 2000)		
	Flow rate for selected gages (1986 to 2000)		


River cells
Drain Cells
MARTIN
LAKE
OKEECHOBEE
PALM BEACH
BROWARD
MIAMI-DADE
MONROE
ATLANTIC
OCEAN
N
W
E
S
Miles
0
5
Lower East Coast
subRegional Model
sfwmd.gov
Prepared by : MAPU
Date: 02/07/06
Map Doc.: canalslecsr_06.mxd

Comment / Question 93: Cell types and calibration targets should be shown together.

Response 93: Please refer to Response 202.

Comment / Question 94: The non-standard MODFLOW packages should be labeled as such, perhaps with the reference.

Response 94: The table will be updated according to this comment.

Comment / Question 95: How are the parameters alpha and Beta selected? Are they calibrated or can they be assigned to specific classes of vegetation or areas?

Response 95: Please refer to Response 54.

Comment / Question 96: Does this package route water, such that the gradient is a computed as in MODFLOW (cell to cell)?

Response 96: The Wetland Package does compute a gradient in MODFLOW (i.e., cell by cell flow) by simulating 2-D overland flow. Where the Wetland Package cells are active, the groundwater and surface water are integrated.

Comment / Question 97: Why are source / sink sets in the Diversion Package defined based on particle travel times of one to two times the length of the time discretization? What does this mean?

Response 97: This statement is a recommendation to the model user. When the Diversion Package is used in combination with the Wetland Package, the overland flow routing is done with the WTL Package. The particle travel times can help define the zone of influence where the diverted water should be extracted from the source or delivered to the sink area.

Comment / Question 98: Clarify what happens to the proportion of pumped water that is above the assigned efficiency (such as the 10% of a 90% efficient pumping rate)?

Response 98: If the efficiency is not 100 percent, the percentage above the specified efficiency is removed from the model domain.

Comment / Question 99: Please identify, preferably in a table with figures, all different types of uses of this package, and clarify how it is used for each. Please clarify why the user must input qc if there are also rules that govern the flow (if the user must enter qc values that are based on historic or estimated flows, how are operating rules simultaneously used?). The only types of uses described represent pumping from surface water sources.

Response 99: MAS will create a table of Diversion Package applications. Qc is a target that is associated with the capacity of the structure.

Comment / Question 100: Please clarify whether the proportion of water coming from all source cells in a group is fixed.

Response 100: The proportion of water coming from all source cells in a group is fixed for that stress period. If 100 cfs is removed from 10 source cells, 10 cfs will be removed from each of the cells.

Comment / Question 101: Please clarify whether the proportion of water going to all sink cells in a group is fixed.

Response 101: The proportion of water going into all sink cells in a group is fixed for that stress period. If 100 cfs is delivered to 10 sink cells, 10 cfs will be applied to each of the cells.

Comment / Question 102: Is the deposition of water lagged by a timestep after removal or is it instantaneous?

Response 102: It is instantaneous.

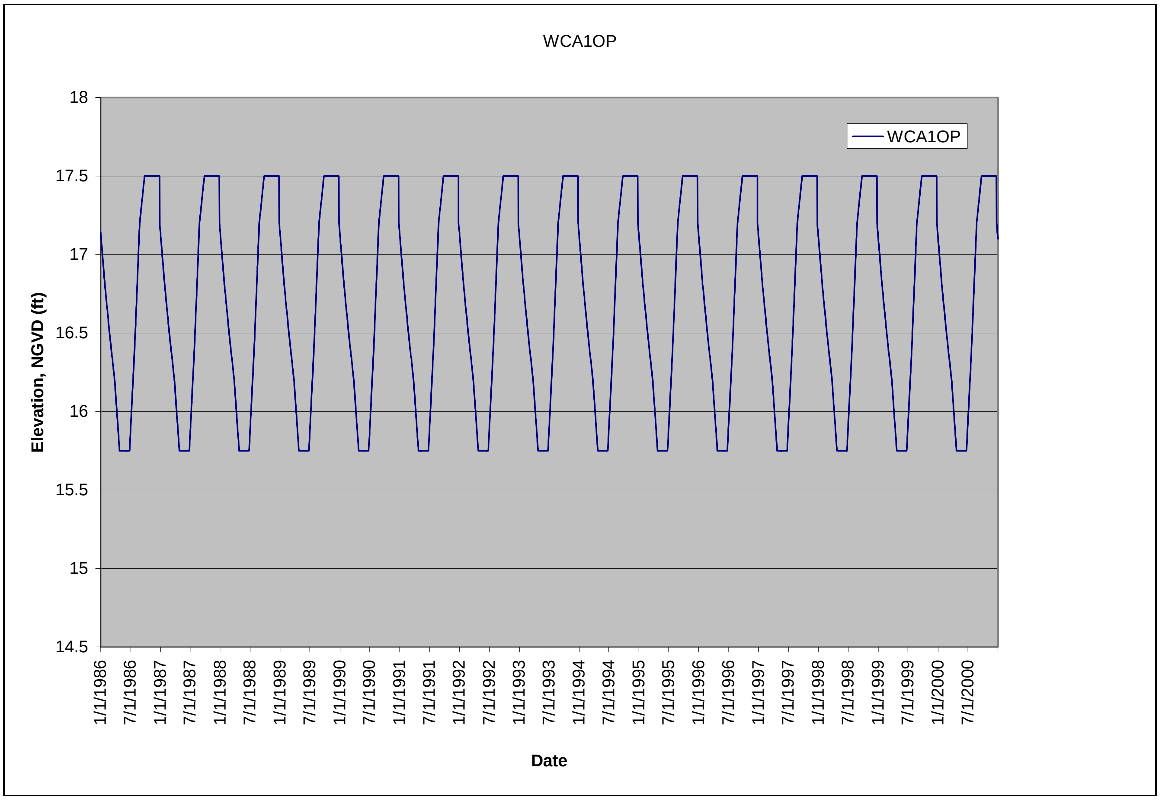
Comment / Question 103: Later in the report, a figure with "flows" is shown (figure 64) and it is stated that this refers to the RDF and Diversion packages. Why such a limited area and why this particular area?

Response 103: The RDF and Diversion Packages were used to simulate the surface water flow through the canal structures and wetland areas in the watershed. This method was developed and applied to a specific project in order to quantify the flows that contribute to a river and its tributaries, which is a smaller sub-set of the model domain. The flows simulated in this manner are the ones shown in Figure 64. Please note that the other canals are modeled with the River and Drain Packages.

Figure 68 shows the other areas where the RDF and Diversion Packages were used.

Comment / Question 104: Does the RDF package use historical operational rules in the calibration? Do they exist for the period of record? Haven't the changed? How is this accounted for?

Response 104: The RDF Package uses operational schedules which must be implemented in the model as daily stages. This package has the ability to change the schedule each stress period. Therefore, if the schedule changes halfway through the calibration period, the changes can be implemented. An example is presented below for the RDF Package; the stages are provided in the UGEN Package.



Comment / Question 105: Is there always a pair wise set of cells for any diversion via the Diversion Package, or can one source cell provide water to multiple sink cells within the Diversion Package? If the latter is true, is this an ill-posed problem when the reverse condition is in effect where multiple sink cells divert water to a single source cell? How was the Diversion Package validated?

Response 105: Yes, but it is one to many. The user should design the model to avoid the many to one situation. The Diversion Package can be set in one direction – not both directions.

Comment / Question 106: Please graphically show the paired cells using the RDF package.

Response 106: This graphic will be prepared by MAS before the end of the Peer Review process.

Comment / Question 107: Please reword, especially to clarify what happens in the code if qc is specified, yet the head in the sink is below the specified maximum level. Does the model print the different between the input qc and the flow values actually simulated?

Response 107: The model prints the difference between the input qc and the flow values actually simulated.

Comment / Question 108: Don't understand the statement "If the model is re-calibrated, the trigger package must then be re-calibrated as well".

Response 108: The Trigger Package is not used during calibration – only in predictive applications. If the calibration changes, then the Trigger Package input was must re-evaluated.

Comment / Question 109: This package seems to be potentially dangerous if great care is not used in detecting when cutbacks have been initiated--hopefully there is detailed output that tells exactly what is being done?

Response 109: There is detailed output that shows exactly where and what is being cutback. This is part of the Trigger calibration process, which occurs after model calibration. Please refer to Background Materials, Trigger Package Documentation to view the type of output produced.

Comment / Question 110: UGEN: The 2nd file, the observation file, is field data, not modeled?

Response 110: Correct.

Comment / Question 111: Why is the SIP solver used when there are several more efficient and robust solvers now available for MODFLOW?

Response 111: This SIP solver was selected, but we tried using the PCG also. We would like to compare the solutions from both solvers in the final documentation.

Comment / Question 112: SIP: How often is HCLOSEMAX or NOSTOP invoked? Has this had any negative effect on the mass balance?

Response 112: With a closure criteria less than 0.005, the percent discrepancy is less than one percent the entire simulation. With a closure criteria less than 0.001, the percent discrepancy is less than 0.1 percent the entire simulation; however, the computer time increases. When the maximum iterations are set to 150 and the closure criteria 0.005, HCLOSEMAX is invoked approximately 10-20 times.

Comment / Question 113: With only a limited number of observation locations, how are for example canal stages assigned to the entire model domain?

Response 113: The observation locations presented in Figures 78 to 81 are used as calibration targets. The SFWMD's hydrologic database, DBHydro contains a lot of information for the canal stages.

Comment / Question 114: Here please mention that 3 model layers were selected to be used in the LECsR model. Table 8 contrasts 3 versus 4 layer model requirements. Currently, the 3 layer usage is not mentioned until page 88.

Response 114: The vertical discretization of the model layers is presented in the next section on page 88. The idea is to present the conceptual model, first, in Chapter 2 and then present the model design, second, in Chapter 3.

Comment / Question 115: Does "WMM" signify the coarse SFWMM properties?

Response 115: Yes.

Comment / Question 116: What is the "Operations" package?

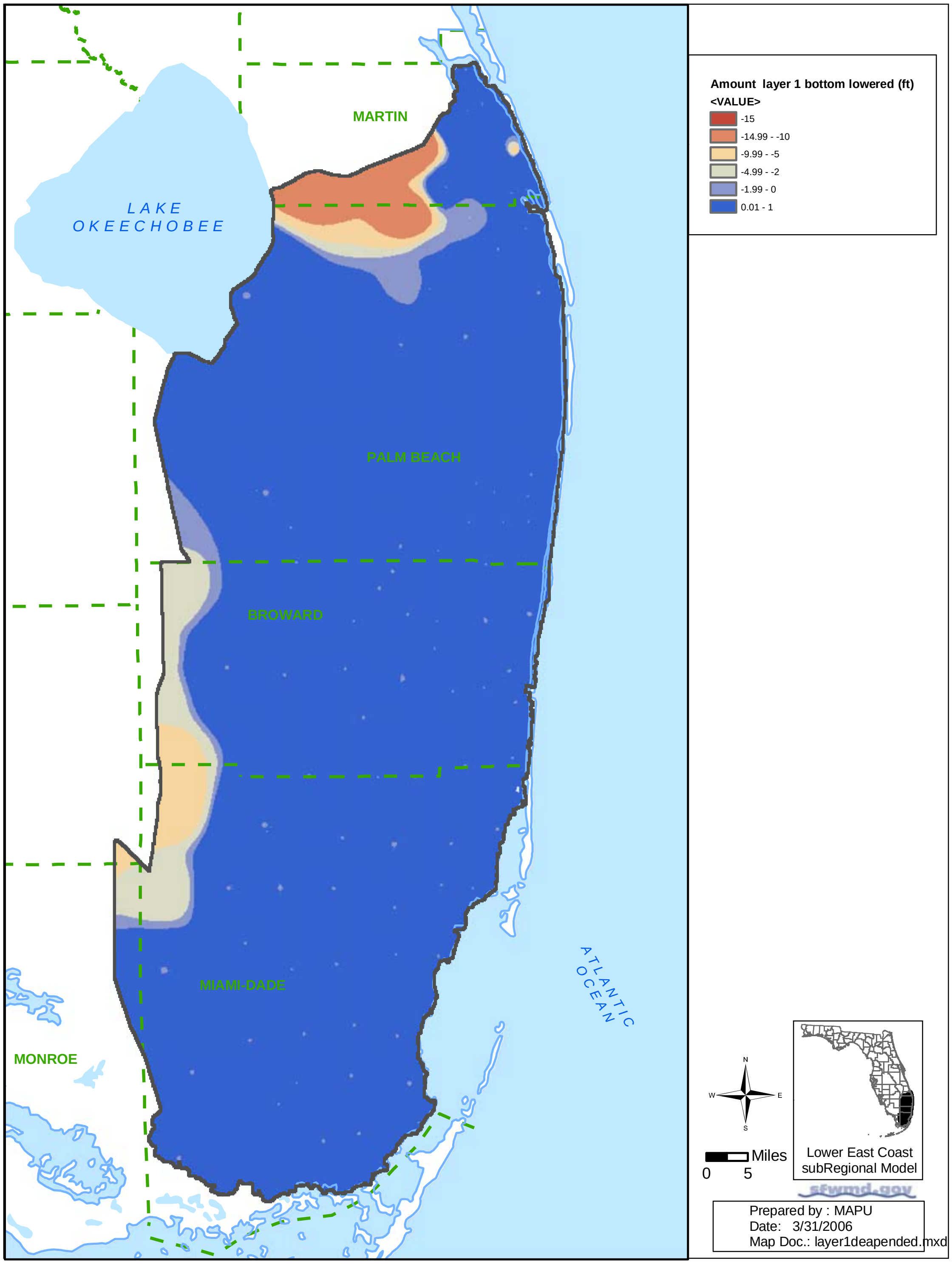
Response 116: "Operations" was referring to the RDF and Diversion Packages. The sentence was re-worded as, "Daily input data were available to construct the hydrologic packages (i.e., ET, Recharge, River, Drain, General Head Boundary, RDF and Diversions) and excluded pumping stresses."

Comment / Question 117: The per byte cost of disk storage has become very low over the past several years. Designing the model structure to minimize disk storage requirements seems rather limiting given the low cost of disk storage.

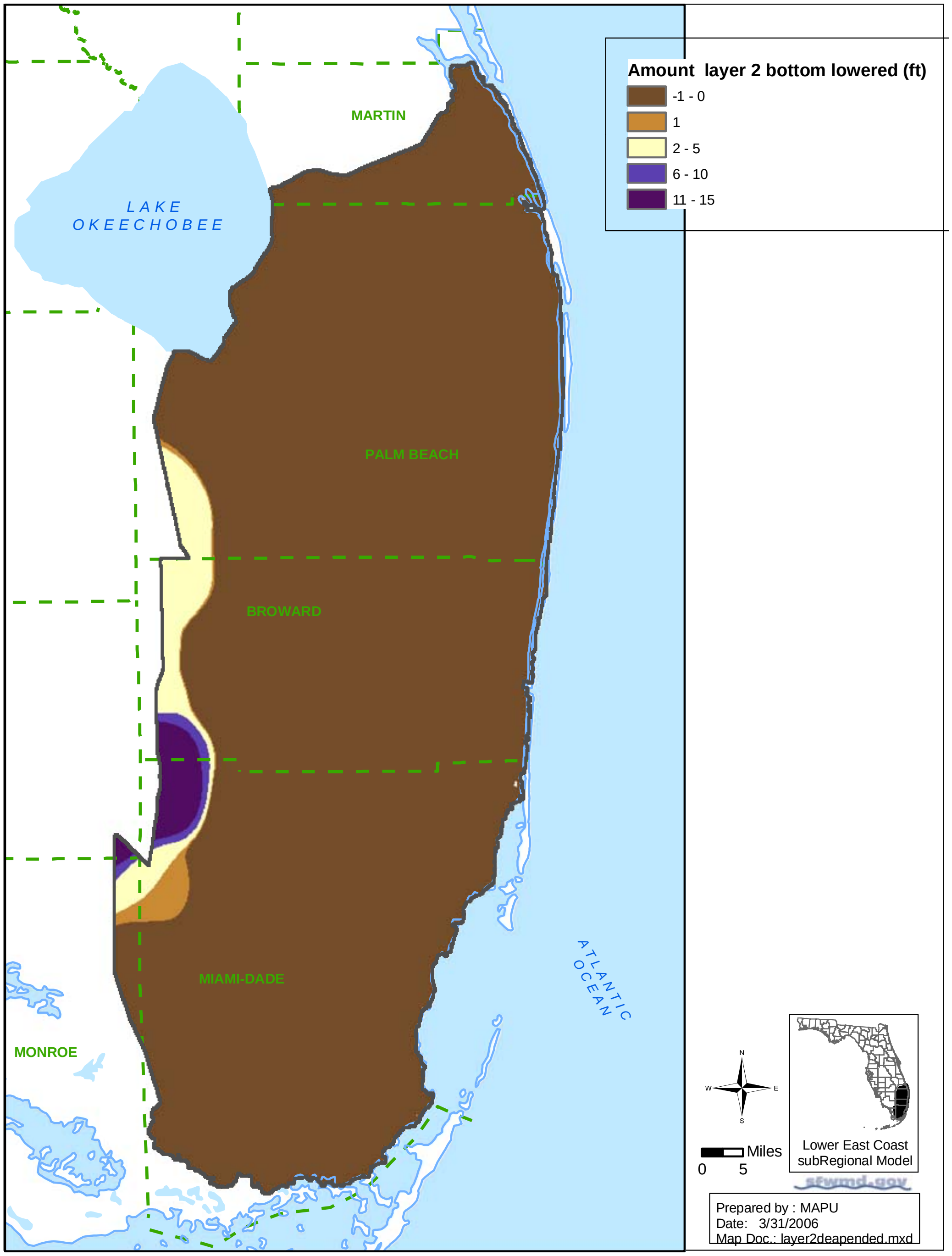
Response 117: At the time of model development, the computer infrastructure for MAS was limited. When the Information Technology Department was re-structured, there was a change in policy and MAS worked with IT to develop a proof of concept for better infrastructure.

Comment / Question 118: Could you give us an indication about how large an area required adjustment (# of cells, a graphic, etc)?

Response 118: Figures are provided below.



Amount layer 1 bottom lowered (ft)
<VALUE>
-15
-14.99 - -10
-9.99 - -5
-4.99 - -2
-1.99 - 0
0.01 - 1
MARTIN
LAKE OKEECHOBEE
PALM BEACH
BROWARD
MIAMI-DADE
MONROE
ATLANTIC OCEAN
N
S
W
E
Miles
0 5
Lower East Coast subRegional Model
sfwmd.gov
Prepared by : MAPU
Date: 3/31/2006
Map Doc.: layer1deapended.mxd



Comment / Question 119: Why is the bottom of model above the bottom of the G-2330 log?

Response 119: The cross section line does not cross exactly at G2330. The number in prentices next to each well is the distance the line is in feet from the well. At the well the depth of layer 3 is -162 NGVD. One cell over the depth of layer 3 is -38 NGVD.

Comment / Question 120: At least two vertical model grid cross-sections (north-south, west-east) should be shown to complement the horizontal grid shown in Figure 46.

Response 120: This comment will be seriously considered. There are 5 cross-sections as shown in Figures 18 to 22.

Comment / Question 121: "K" is usually reserved for hydraulic conductivity and "H" is reserved for hydraulic head. It seems unconventional to use "H" to signify hydraulic conductivity.

Response 121: Point taken. MAS will standardize the variable definition.

Comment / Question 122: The "1 - 3,530 ft/day" band of K covers the entire northern half of Layer 2 within the model domain. Would a logarithmic scale better show spatial variability in K in this area?

Response 122: MAS can try using a different scale.

Comment / Question 123: The discussion of Ss is inconsistent with what appears to have been done. First a specific storage of 1e-5 is cited and said to have been used to determine S. The equation then implies that a value of 5.01 e-5 was used.

Response 123: Ss= Thickness of layer*5.0 e-5

Comment / Question 124: What causes the circular patterns of Vcont shown in the figures? Are they based on actual data or artifacts of the interpolation methodology?

Response 124: They are artifacts of the interpolation methodology.

Comment / Question 125: What is the approximate error in assigning an average elevation across a cell--that is how much variability is there within a cell?

Response 125: The variability across a cell will be greatly influenced by the resolution of the data and whether or not the data have been re-sampled. Table 1 shows that typically the data resolution ranges from 5 ft to 500 ft. In areas where LIDAR was used, the variation across a cell could be 10 ft, especially near the coastal ridge in North Palm Beach.

Comment / Question 126: Why a sy of 0.9 for ponded water (isn't it really 1.0)? What is the basis for a difference in peat/muck sy ("mainly 0.3")?

Response 126: The constant, 1.0 was not chosen since there is still vegetation in the ponded areas. In this model, 0.3 represents the sy in the muck and aquifer.

Comment / Question 127: Please clarify. Is the top elevation of muck the same as what would be the ground surface elevation in a modflow2000 implementation?

Response 127: Yes.

Comment / Question 128: Can we see a graphic showing the areal distribution of Kadlec coefficient? I am curious about spatial variability.

Response 128: This graphic will be created.

Comment / Question 129: How accurately were the depths of surface water predicted in wetlands cells during calibration?

Response 129: Please refer to Appendix B which shows calibration plots of groundwater wells and surface water gages. Then, refer to Figures 78 to 81 to locate the groundwater wells and surface water gages. Groundwater wells are labeled with red dots; surface water gages are labeled with blue dots.

Comment / Question 130: The density of canals, drains, and flows is quite high. How many calibration target cells are shared by one of these features?

Response 130: Please see the following table.

Station	Cell Type	Station	Cell Type
PB1491	River	G3621	River
G968	River	G3619	River
KROME	River	G3620	River
G3074	River	PB685	River
G1487	River	PB1661	River
PB1684	River	PB1680	River
G2034	River	L30L67A	River
G2033	River	L67A	River
G1316	River	PB1662	Drain
G1315	River	PB561	Drain

G2852	River	PB689	Drain
G3551	River	G2739	Drain
G3558	River	PB1642	Drain
G3559	River	NP-35	GHB

Comment / Question 131: What were the criteria for using RDF or Diversion Packages in favor of Rivers?

Response 131: This method was developed in response to a modeling request. The request required the model to be able to quantify flows and runoff to tributaries and canals rather than using the River package.

Comment / Question 132: How are "streams" and "culverts" handled within the various add-on packages? These features have not been previously discussed. Is this truly the stream package, or is it equivalent to "flows" using RDF or Diversion? A culvert category is shown. How is this modeled? Why the distinction?

Response 132: The figures will be modified to reflect that the canals labeled as class "Streams" are modeled with the River package. These cells behave more like surface water bodies. We do not use the Stream package in the model. The culverts are not modeled. They will be taken out of the canal figures.

Comment / Question 133: The use of the standard well package to remove water from the Grassy Water Preserve is because it goes to the WTP for treatment and then is distributed (consumptive use), right?

Response 133: Yes, the water ends up in a water treatment plant and is then used for consumptive use.

Comment / Question 134: Since the canals are surface features, why are they represented in all layers? A divide would still be represented if the layers 2 and 3 cells were active. Concern is that you are allowing too much flow.

Response 134: If the aquifer is not under stress, the heads in layers 1, 2 and 3 will be very similar. This gives us the basis for using the same level for each layer. However, the conductance is computed using each layer's hydraulic conductivity, which is low (e.g.,

Comment / Question 135: How were conductances computed for the non-tidal areas?

Response 135: The conductances in the non-tidal areas were computed using the MODFLOW equation for conductance, C_b, which is defined as:

$$C_b = \frac{K_b MW}{L}$$

Where K_b is the horizontal hydraulic conductivity in the general head cell, MW is the cross-sectional area of the general head cell (where the flow will pass through), and L is the distance between the head at the boundary and the head in the aquifer.

Comment / Question 136: What is the basis for equation 5? What is the typical amount of reduction?

Response 136: Equation 5 was created to generalize the conductances regionally, so that individual cell changes were not made to the general head cells. It's an approximation for vertical flow along the saltwater interface that will reduce the flow in the lower model layers where the density of saltwater is greater.

The pre-processing program for GHB's was run with no correction to the conductance and compared to the Table 9, which contains the average corrected conductances. The average reduction in conductance (ft^2/day) for each section is shown in the following table. The positive values show reductions in most of the sections in the bottom layers.

Model Layers	Reduction (+) for Section 1	Reduction (+) for Section 2	Reduction (+) for Section 3	Reduction (+) for Section 4
1	-71	-6074	-12190	-8052
2	3467	91352	-15028	3150
3	38920	101879	9740	55853

Comment / Question 137: Please explain why no equilibrium (steady state) simulation was run during the calibration just to see what the results would be. If one was run, briefly state what the results were, to justify no further use of steady-state runs.

Response 137: A steady-state simulation can not be done with the SFWMD's version of MODFLOW. The add-on packages were not programmed to use the steady-state flag in the BCF Package; therefore a steady-state simulation was not executed.

Comment / Question 138: Reword to state that initial heads for a pre-calibration run were created by subtracting 2 feet from the ground surface elevation. Please clarify. Also, please explain and justify how initial layer 2 and 3 heads were prepared.

Response 138: Initially layer 2 and 3 heads were developed like those in layer 1 – by subtracting from the topography. After the pseudo-steady-state runs were finished, the new heads for layers 1, 2 and 3 were used as the initial conditions.

Comment / Question 139: What does "stretched to one standard deviation" mean?

Response 139: This figure was produced in ESRI’s ArcMap. To symbolize the data, it was stretched instead of classified. Stretching results in a gradual change in categories.

Comment / Question 140: “The Et and recharge values that were developed in this way were held relatively constant in the model throughout the calibrations process". You mean that the unsat zone model derived values were not changed in the MODFLOW model, not that they were constant, right?

Response 140: Yes, the et and recharge rates entered in MODFLOW’s ET and Recharge Package are not constant.

Comment / Question 141: Please reword. I assume that deep percolation is what percolates downward through the root zone, and that the deep percolation volume consists of anything above soil field capacity. Clarify whether a time lag is used, or whether any percolating water reaches the saturated zone in the same day that it departs the root zone.

Response 141: This section will be clarified.

Comment / Question 142: As in a previous comment, please summarize in a table and on a figure where different approaches for determining ET and Recharge are used, and, the ranges of parameter values used for those approaches.

Response 142: This section will be clarified. Please refer to Responses 80 to 86.

Comment / Question 143: I'm not sure I understand the ET implementation. Is the MODFLOW ET package eventually used?

Response 143: Yes, please refer to Responses 80 to 86.

Comment / Question 144: Could we see a table or graphic showing ET extinction depths spatially?

Response 144: MAS will create a figure.

Comment / Question 145: Please clarify how frequently the step-wise post-audit will be conducted, or what will determine the frequency.

Response 145: This will be clarified in the final documentation. MAS expects this type of clarification will require a management decision.

Comment / Question 146: It would be useful to clarify how one can download the LECsR model, and the graphics visualizer.

Response 146: MAS will include a section on how model inputs and output can be viewed and downloaded. The LECsR Model and source code are in the public domain, other software that the model uses requires a license (e.g. ArcGIS and FORTRAN).

Comment / Question 147: The flow rate variable is qc, but only q is shown in the upper figure (i.e., the subscript "c" is missing) and there is no qc shown in the lower figure, only the flow direction arrow.

Response 147: The Editorial Comments in Q147 – Q170 will be considered and typographical errors shall be corrected.

Comment / Question 148: The cell size column should be moved to the third column from the left. If columns 1 and 2 are the numbers of WMM rows and columns, the column headings should state that.

Response 148: This table will be re-formatted.

Comment / Question 149: Table 8 is not called out. Moreover, it does not provide much usable information in its current state.

Response 149: MAS will review this table. The purpose of the table is to support our decision-making process when designing the model grid.

Comment / Question 150: The discussion of the SFWMD computer system is interesting, probably necessary, but detracts from the discussion on spatial and temporal grid design. Consider moving it.

Response 150: MAS will seriously consider this comment.

Comment / Question 151: Need to have color code in legend for model layers.

Response 151: Legend for layers will be added.

Comment / Question 152: The numbers in the legend (which are negative) appear to be elevations, not thickness.

Response 152: These figures have been corrected and posted to the Web Board

Comment / Question 153: Specific storage is the volume of water released from storage per unit change in head per unit volume of saturated formation, not unit change of aquifer as stated in the text. Further, specific storage has units of 1/L. What are the units for the specific storage shown here at 1X10-5?

Response 153: The units are 1/ft for the constant 1x10-5. The following equation was used to calculate storativity. The units for storativity, S are dimensionless.

$S = 5.0\,10^{-5} b$

Comment / Question 154: Figures 55 and 56 are the wrong figures.

Response 154: Please refer to Response 152.

Comment / Question 155: The parameter definitions for equation 2 include Kzc, which is not included in equation 2. I think that the discussion refers to another Vcont equation in MODFLOW, which incorporates confining beds.

Response 155: There was a typo. The sentence now reads, “where z_u and z_l are the thickness of the upper and lower layers (ft), K_{zu} and K_{zl} are the vertical hydraulic conductivities for the upper and lower layers (ft/day) and K_{zc} is the hydraulic conductivity for the confining unit.”

Comment / Question 156: Hydraulic conductivity is referenced as "K", but previously (page 98) hydraulic conductivity is referenced as "H". Hydraulic conductivity should be referenced as "K".

Response 156: Please refer to Response 121.

Comment / Question 157: The discussion on selection of anisotropy is weak. An explanation related to geological factors would be more appropriate.

Response 157: MAS will seriously consider this comment.

Comment / Question 158: What is meant by "small (less than 50 acres) isolated wetlands were dissolved out of the active wetland boundary"? Not included? If so, this is probably a reasonable assumption as 50 acres is about 4 cells.

Response 158: Yes, small (less than 50 acres) isolated wetlands were not included in the active wetland boundary.

Comment / Question 159: Please show a representative cross-section of a row of cells that includes some wetland cells and levees. This should include top and bottom elevations, and representative conductances should be named.

Response 159: MAS will seriously consider this comment.

Comment / Question 160: "K" is used to represent the Kadlec coefficient here. This becomes confusing when "K" was previously used to represent hydraulic conductivity.

Response 160: Please refer to Response 121.

Comment / Question 161: Are the specific yield of the "surface water body" and the "wetland water body" referred to in the same sentence, the same thing?

Response 161: No.

Comment / Question 162: Line 11 refers to "hydraulic conductance" but the subject is Kadlec conductance. Is hydraulic conductance what is meant here?

Response 162: Kadlec may be referred to as hydraulic conductance coefficient for overland flow.

Comment / Question 163: Is the grid resolution coarser than the dense canal system shown in this figure? It may be useful to provide a higher resolution (blow-up) figure showing the grid structure and the assignment of the canal segments as rivers in the model.

Response 163: MAS will seriously consider this comment.

Comment / Question 164: There is no reference to Figure 68 in the text. The numbering scheme in Figure 68 needs to be explained. The figure needs a legend added to it. Without any discussion of the figure in the text, it is difficult to understand what information is being conveyed in this figure.

Response 164: This figure will be revised and a discussion will ensue.

Comment / Question 165: Leb is not defined at the point in the text where it is first introduced.

Response 165: MAS will correct the placement of the definition.

Comment / Question 166: Figure 69 is referenced in the text after Figure 70. The figure numbers should be reversed.

Response 166: Figure numbering will be corrected.

Comment / Question 167: What are the units of the data shown in Table 9?

Response 167: The units are ft^2/day.

Comment / Question 168: Reword. ‘the user is prevented from executing a steady-state run’ seems inaccurate. MODFLOW will let one do it, even if it was only calibrated using transient runs.

Response 168: Please refer to Response 137.

Comment / Question 169: Please replace ‘for a length of time’ with ‘for sufficient time that heads become relatively steady’.

Response 169: This sentence will be re-worded.

Comment / Question 170: There is a previously referenced Equ. 5 on page 119. Further, Equ. 6 is shown before Equ. 5 on page 126.

Response 170: The equation numbering will be corrected.

Comment / Question 171: I don't believe equation 7 is from MODFLOW

Response 171: This equation is based on the MODFLOW equation for computing ET.

Chapter 4

Comment / Question 172: "calibration was achieved primarily by adjusting parameters within pre-specified ranges to better match computed water levels and structure flows with the observed histrorical records" I see no comparsion to structure flows (except figures 94-96). Is the statement in the report inaccurate or did you just not report on it?

Response 172: The model was primarily calibrated to surface water gages and groundwater wells. Flows were only calibrated to monthly values for the three structures in North Palm Beach. These include the C-18 West weir, structure G-92 and flows over the Lainhart Dam. Flow calibration statistics will be added to the chapter.

Comment / Question 173: The introductory statements seem to imply the hydraulic conductivity was adjusted as a part of the calibration process. However, Table 11 and the related discussion implies that Cghb, Ccanal, bcanal, Sywetlands/mck, Kwetlands were the primary parameters. Exactly what parameters were modified as a result of calibration?

Response 173: The above referenced parameters were the principle ones modified during the calibration procedure. Hydraulic conductivity was not altered with the exception of the City of Fort Lauderdale wellfield (G-2395). However, calibration for this well was not achieved yet. The reason why hydraulic conductivities were not modified was that these models had previously been calibrated when they were county level models so we tried to preserve the properties for this parameter in the revised model.

Comment / Question 174: This states that daily rainfall; ET, etc. are used as hydrological inputs. However the previous chapter indicates that the daily rates are inputs to algorithms that convert them into average values that are actually used in the calibration. The calibration chapter needs to have clear summaries and flowcharts showing how all data is used, and assumptions. This will help a future user to identify model validity for other situations, and to know how to prepare data for those situations.

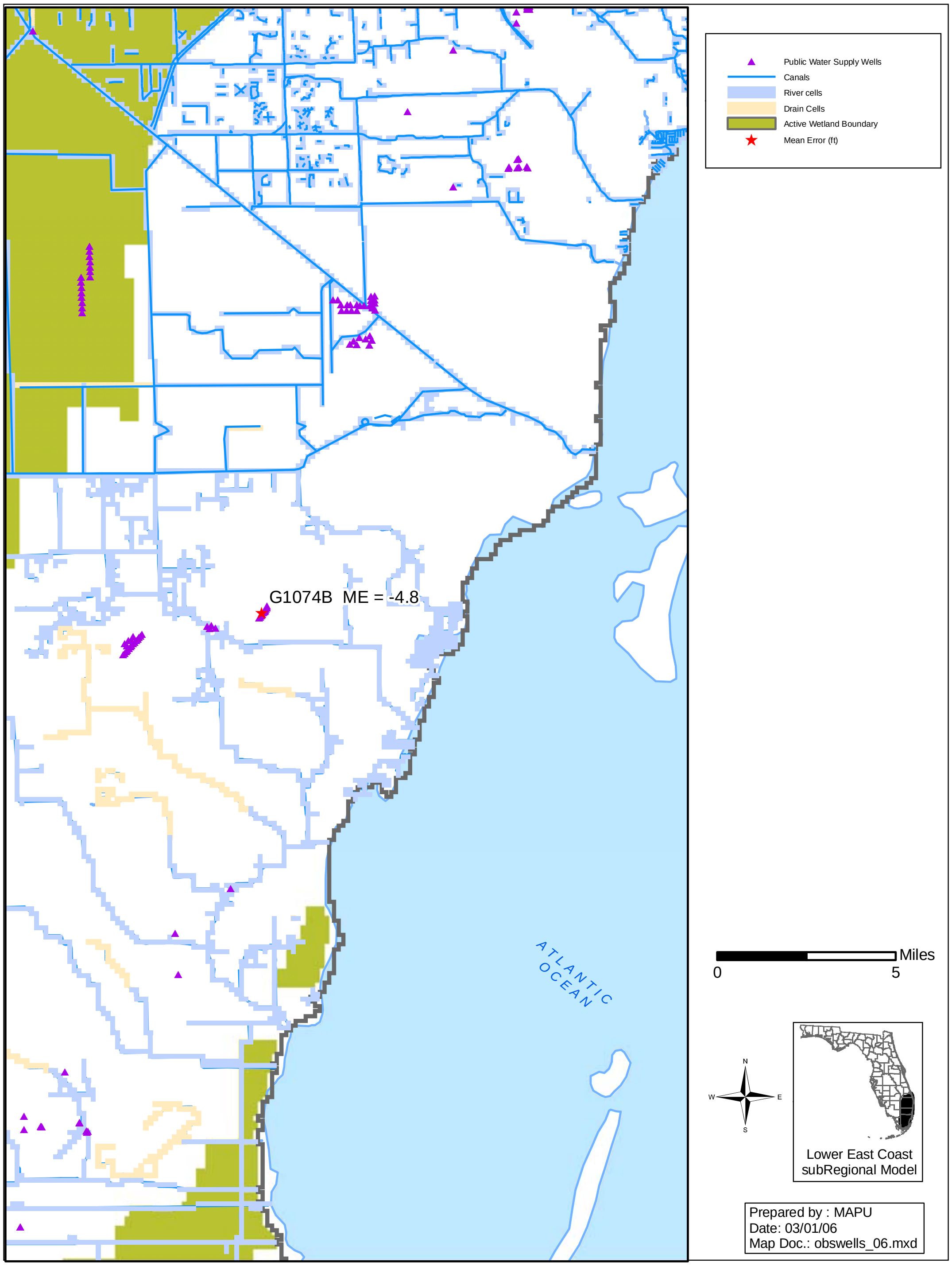
Response 174: Summaries and flowcharts will be added to the final documentation clarifying how the data is used and with what assumptions.

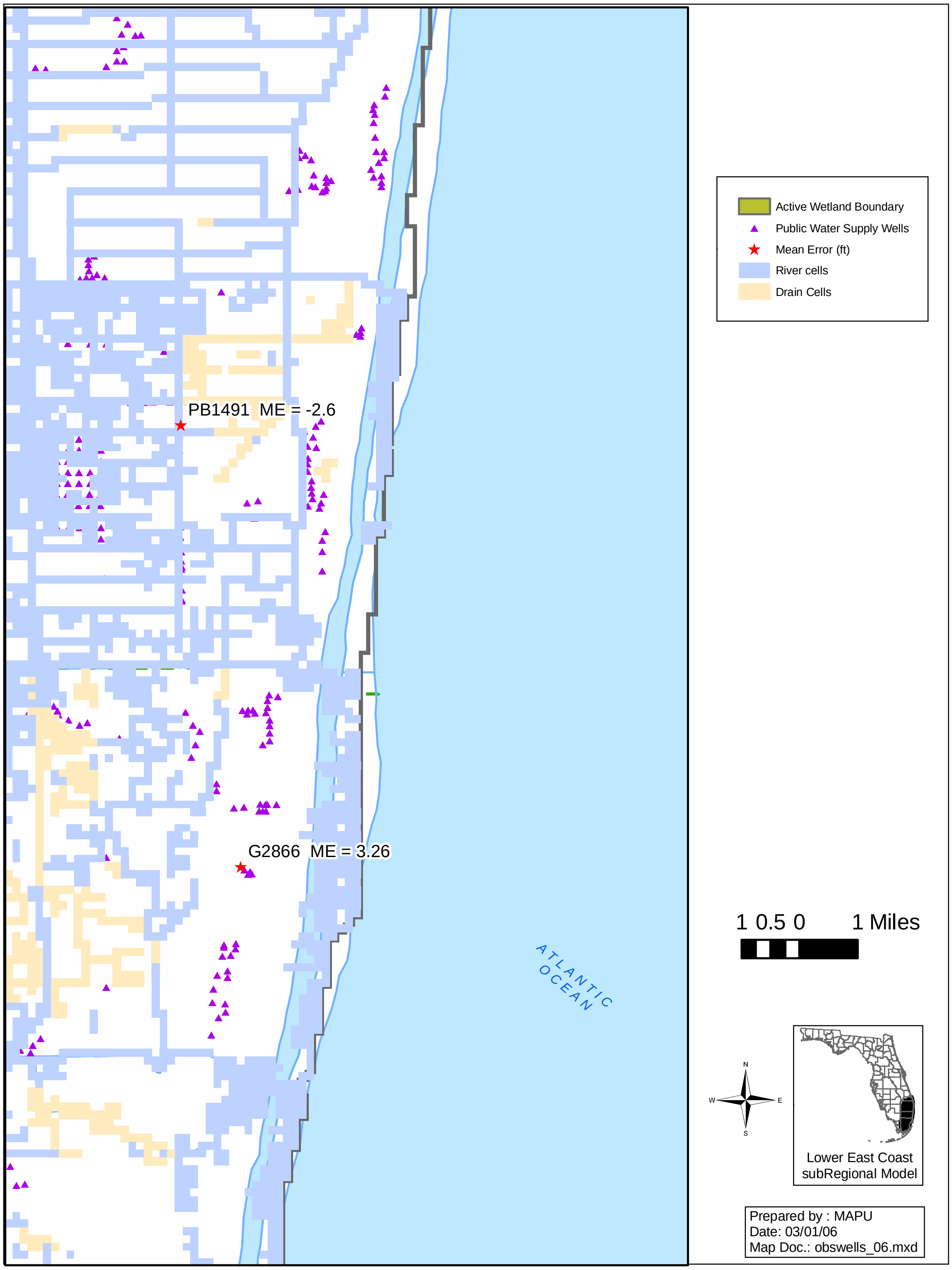
Comment / Question 175: This is a very impressive and complex modeling effort. Much very good work has been done, and the report contains much valuable information. However, a future model user would benefit from some Chapter 4 reorganization, clarification, and summary. For example, to better know how well the model is functioning for particular purposes, it is important to see grids or maps simultaneously spatially locating: - all different types of model cells (cells that use different boundary conditions and flow packages),- heads or flows that are inputs to the model. - monitored and computed state variables, with special note of those for which accuracy is particularly important. - soft data that can be used to confirm reasonableness of predictions (including extent and depth of ponding) - computed state variables that are undesirably inaccurate. Chapter 4 should be enhanced to systematically and spatially present such information. SFWMD should use that information to provide guidance to a future model user.

Response 175: Chapter 4 will be revised and enhanced as requested but further discussion and direction from the Peer Review Panel is required.

Maps of cell-based GHB, Rivers, Drains, Wells and Wetlands have been created. Observation network of groundwater wells and surface water gages have been added to these maps also. Soft calibration points were to these maps. Please refer to maps under Response 202.

Additional graphics showing the mean error +/- 2.5 have been created.


Public Water Supply Wells
Canals
River cells
Drain Cells
Active Wetland Boundary
Mean Error (ft)
G1074B ME = -4.8
ATLANTIC OCEAN
Miles
0
5
N
W
E
S
Lower East Coast subRegional Model
Prepared by : MAPU
Date: 03/01/06
Map Doc.: obswells_06.mxd



PB1491 ME = -2.6
G2866 ME = 3.26
ATLANTIC OCEAN
Active Wetland Boundary
Public Water Supply Wells
Mean Error (ft)
River cells
Drain Cells
1 0.5 0 1 Miles
N
S
E
W
Lower East Coast subRegional Model
Prepared by : MAPU
Date: 03/01/06
Map Doc.: obswells_06.mxd

Comment / Question 176: Provide metrics to describe surface water head and flow calibration accuracy.

Response 176: This will be provided for the three structures previously discussed and a general comparison of surface water flow will also be conducted in other areas of the model domain.

Comment / Question 177: Provide figures showing the spatial distribution of parameters used in sensitivity analysis.

Response 177: A map will be provided which will highlight the main areas which were modified during the calibration process including the parameters changed.

Comment / Question 178: Text states that during any calibration iteration if "significant improvement was observed" the model was permanently modified. What was considered "significant improvement"? What statistical tests were applied?

Response 178: This was conducted on a qualitative basis. Changes were made to the model and the statistics were generated for that particular simulation. These statistics (ME, MAE and RMSE) were then compared to the "working calibrated model" to determine if the revision improved or worsen the model for each individual well. If improvements were noted in the area where the changes were made without causing other areas to have there calibration impacted, then the changes were kept.

Comment / Question 179: Why were "[n]o automated calibration tools" used in the calibration process, especially for fine tuning the model once the manual calibration was completed?

Response 179: Automated calibration tools were not utilized at this time to refine the calibration because staff was unsure as to how long it would take to modify the tools to be able to handle the wetlands, diversions and other additional nonstandard MODFLOW packages utilized in the model development.

Comment / Question 180: A stronger argument for the calibration target of +/- 1.0 ft for 75% of the simulation period than "historically used" needs to be made. This target seems totally arbitrary. The calibration target(s) should be determined considering the intended purpose of the model, the legal/political implications of model predictions, the variety of anticipated model applications, the natural variability in input parameters, etc. Why is +/- 1.0 ft over 75% of the simulation time better or worse than, say, +/- 1.25 ft for 80% of the simulation period?

Response 180: The primary calibration criteria include the mean error, the absolute mean error and the root mean square error which is consistent with Anderson and Woessner (1992) and the ASTM standards. The inclusion of the +/- 1.0 foot for 75 percent of the time is more of a legacy criteria. The previous county levels models utilized this calibration criteria as their primary target, therefore it was included in this report to allow the user to compare LECsR calibration with the previous county level models even though the calibration period was significantly longer than the previous models. The text will be modified to more accurately reflect the inclusion of these criteria in the document.

Comment / Question 181: One way of evaluating calibration quality (the selected method) for a transient model is to compute a statistic for the duration of the calibration for each well and then plot these statistics spatially (average time, look spatially). Another method is to compute a statistic for each time period and then plot these statistics versus time (average space, look temporally). The first is good for looking at spatial bias, the second at temporal bias. I believe it would be beneficial for the SFWMD to consider the 2nd method as well. Of particular interest is the ability of the model to replicate wet and dry periods. It would be interesting to plot mean errors on Figures 85,86, and 87, showing average, wet, and dry conditions.

Response 181: We agree and the mean errors will be included on figures 85, 86 and 87.

Comment / Question 182: A generic example of the calibration criteria, similar to the one provided in the accompanying worksheet in this spreadsheet (Calib Example), should be included as a table in the documentation to demonstrate the differences among the various criteria.

Response 182: An example of the table will be included in the document.

Comment / Question 183: Clarify whether ME is simulated – observed or the other way around.

Response 183: ME, MAE and RMS is observed minus simulated and will be clarified in the text.

Comment / Question 184: Please justify why no ponded water depth or elevation measurements are made and used to provide calibration targets.

Response 184: There is some confusion in the way the calibration data was presented in the report. Actually, there is roughly an equal amount of surface water gages and groundwater wells that were used in the calibration process. The tables and text will be corrected to clarify this issue.

Comment / Question 185: Please explain why no remote sensing data was used to determine the actual size and shape of areas of inundation, and why such was not compared with model calibration results.

Response 185: Remote sensing was utilized in south Miami-Dade County, western Broward County (see figures 87 and 88), north Palm Beach and Martin Counties for estimation of hydropatterns for wetlands were no staff gages or monitoring wells were utilized. The “Soft Calibration” section will be enhanced to include this information.

Comment / Question 186: Philosophically, what is the meaning of the calibration targets? The calibration process in an optimization problem wherein one tries to minimize some function related to the quality of the history match of simulated values to observed values. The calibration targets serve as waypoints in the calibration process. Ultimately, the objective of the calibration exercise is to drive the statistical criteria to zero (or 100%), depending on the criteria. Therefore, rather than running the calibration exercise until the arbitrary targets are met (which they are not), why not run the calibration until either the resources available for the calibration exercise have been exhausted or no additional improvement in the history match can be achieved by any further reasonable manipulation of parameters?

Response 186: We are in the process of doing what is suggested. The targets were selected to bring the model to a reasonable point were should it get challenged it would be defensible from a calibration standpoint. However, further refinement is presently ongoing to achieve a more robust calibration prior to finalizing the document. Any improvements to the model will be included in the final report.

Comment / Question 187: The ME criteria should be much less than the MAE since the ME has a canceling effect of highs and lows. A 0.75 ft is much too high--consider the effect it has on ET and whether wetlands are flooded or not.

Response 187: For the global model statistics we agree and will modify the document to a 0.25 foot target. However, on an individual well basis, this may not be the case. If a well was randomly over predicting and under predicting then that may be the case. However, if a well is consistently over predicting or under predicting (which is generally the case) then the residual would be consistently positive or negative.

Comment / Question 188: The value of "soft" calibration is underestimated. Soft calibration can be more meaningful and telling of the quality of the model in some cases than hard numerical calibration owing to the uncertainty in the observed data, different levels of support (geostatistical) of the observed data, time variance, etc. A section in the calibration chapter could be added that addresses the "soft" evidence to support the claim that the model is suitably calibrated.

Response 188: A section will be added to the document which will address the “soft calibration” issue. This will include the response in question 185 dealing with remote sensing, wetland types and estimated hydropatterns as well as the response in question 221 which is a review of the flow fields.

Comment / Question 189: It appears that the calibration is focused on matching transient water levels in wells. Has any effort been made to match water levels or flows in canals? Since canal stages seem to exert a strong control on groundwater levels, checking stage (where computed) and flows seems important.

Response 189: The model was initially calibrated to matching transient water levels in wells and surface water gages. Only the C-18 canal was calibrated to both flows and canal stages because the majority of the remaining canals are prescribed in the input data sets. The results from the C-18 canal will be incorporated into the calibration section of the document. Also, please see discussion on Question 190.

Comment / Question 190: It appears that water Budget components have not been accounted for as a target. A quantitative check where flows are available and a qualitative check elsewhere is critical.

Response 190: Partial calibration to flows for the entire model domain has not been completed to date. Based upon the number of questions concerning this issue we will include it in the documentation.

Comment / Question 191: Was each model parameter set to its maximum and minimum value and an independent model run made? Was any consideration given to the interdependence of some model parameters on the model results? For example, lowering K while raising S in the same model run.

Response 191: In the initial calibration of the model, several of the parameters were set to high and low values to understand the sensitivity of the model to varying parameters during the calibration process. Specific parameters where maximum and minimum values were include the Kadlec number, specific yield for both the wetlands and none wetlands cells, thickness of the canal soils, and the hydraulic conductivity of the canal sediments. Other parameters where not varied initially to their extreme including hydraulic conductivity and the topography because of the rapid change across the area. Also, during the calibration process we frequently modified two different parameters at the same time with the limitation that they were not in the same area of the model. An example of this would be changing the wetland bottom in Everglades National Park and the ET extinction depth in north Palm Beach.

Comment / Question 192: What type of earth material exhibits a hydraulic conductivity of 100,000 ft/day?

Response 192: The 100,000 ft/day is for the muck layer in Shark River Slough in the Everglades National Park. It was necessary to increase this in the slough to force more water towards Florida Bay. This value was ultimately increased to 500,000 ft/day to adequately calibrate the surface water gages and wells in the slough (see question 201).

Comment / Question 193: Revise this table. Minimum and Maximum Values disagree with the presented definitions. For example, for a minimum canal conductivity of 0.1, one estimates that the original conductivity was 10 (in other words 0.1 x 100). However, from the maximum value of 100, one estimates that the original conductivity was 1 (in other words 100/100).

Response 193: The table was revised as requested.

Comment / Question 194: Please explain what 'tolerance levels' means.

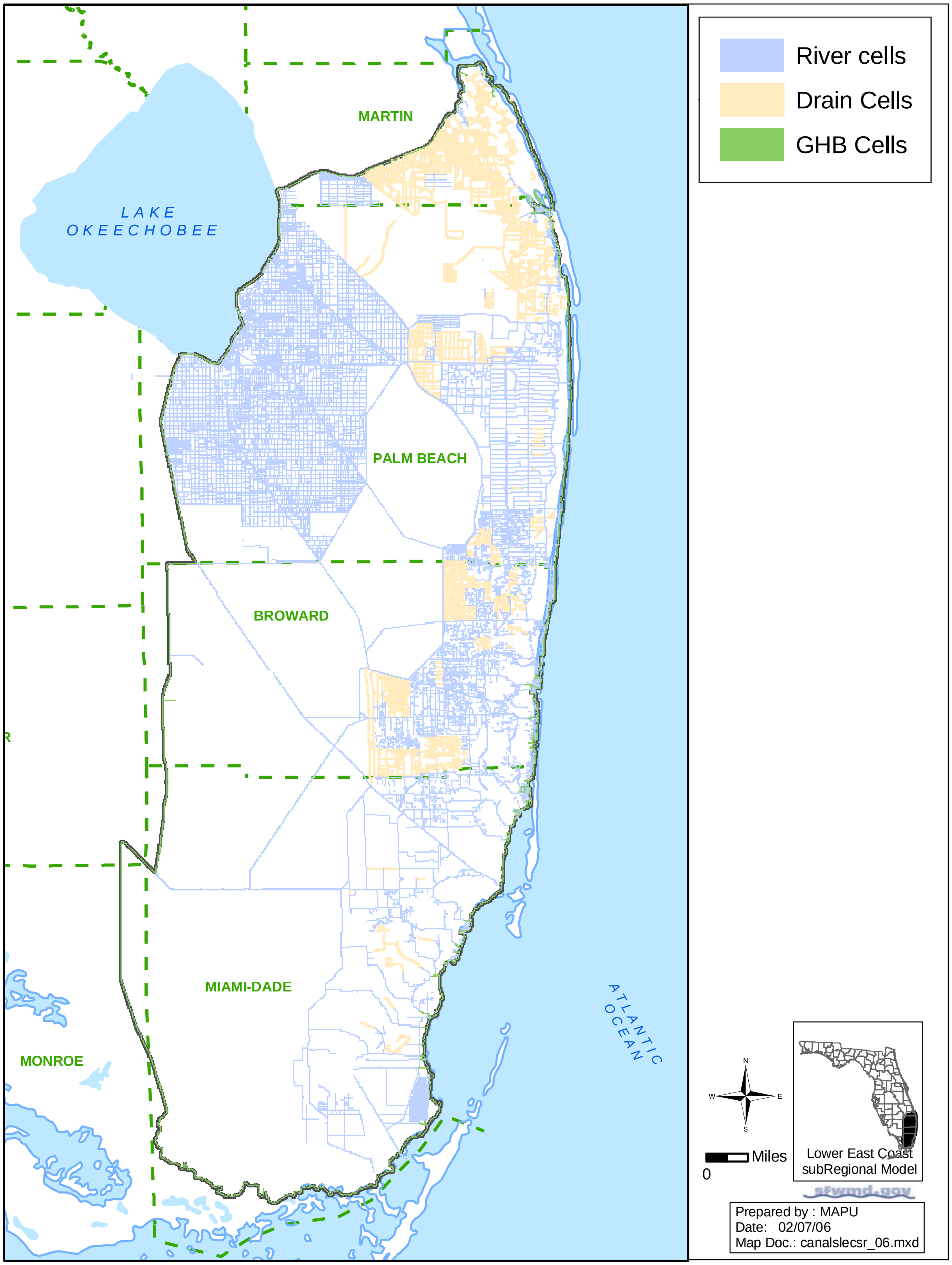
Response 194: This should probably be reworded to Minimum and Maximum Values. Essentially, the tolerance level was the maximum amount of change that would be allowed for a particular parameter during the calibration process. An example would be that if the minimum and maximum values for specific yield of the muck were between 0.2 and 0.8 we would not allow the value to be exceeded in either direction when parameters were adjusted. The only time that a parameter exceeded these levels was for the hydraulic conductivity of the Shark River Slough which was increased to 500,000 ft/day (see question 201).

Comment / Question 195: Please summarize calibration runs, results, and conclusions in a table. Different calibration runs should be numbered. The discussion should refer to the summary table and run numbers. Admittedly, such summarization might begin after some preliminary organizational calibration runs, and after all cell types are properly assigned. After all cell types are determined, runs to improve parameter values should be numbered.

Response 195: A table will be generated which includes the modifications that were made after the preliminary calibration runs. This table will include a summary of the results and the changes made to the model. However, the table will include local identification areas which local stakeholders are familiar with but individuals not familiar with the area may not understand. The table will include those runs were we were specifically identifying an area for improvement and not "what if" type runs.

Comment / Question 196: Please show the location of all rivers and drain cells and groups of such cells for which parameters are common in a figure. If shown elsewhere in the report, it should again be cited here.

Response 196: Figures have been placed in the document.


River cells
Drain Cells
GHB Cells
MARTIN
LAKE OKEECHOBEE
PALM BEACH
BROWARD
MIAMI-DADE
MONROE
ATLANTIC OCEAN
Miles
0
Lower East Coast subRegional Model
Prepared by : MAPU
Date: 02/07/06
Map Doc.: canalslecsr_06.mxd

Comment / Question 197: Please show the location of all wetlands cells and groups of such cells for which parameters are common in a figure. If shown elsewhere in the report, it should again be cited here.

Response 197: Figures will be placed in the documentation.

Comment / Question 198: The location of all MODFLOW ET cells and groups of such cells for which parameters are common should be shown in a figure. If shown elsewhere in the report, it should again be cited here.

Response 198: All active cells include potential ET, extinction depth and ET surface. MAS will cite Figures 61 and 74 and will create an extinction depth figure.

Comment / Question 199: The location of all other types of specialized flow cells and groups of such cells for which parameters are common should be shown in a figure. If shown elsewhere in the report, it should again be cited here.

Response 199: Diversion, GHB and RDF location maps may be placed in the document.

Comment / Question 200: I'm a little concerned that canal conductance may be the single most important parameter, given the density of canals. Can you show a graphic or discuss how much variability there was imparted on a cell-by-cell basis?

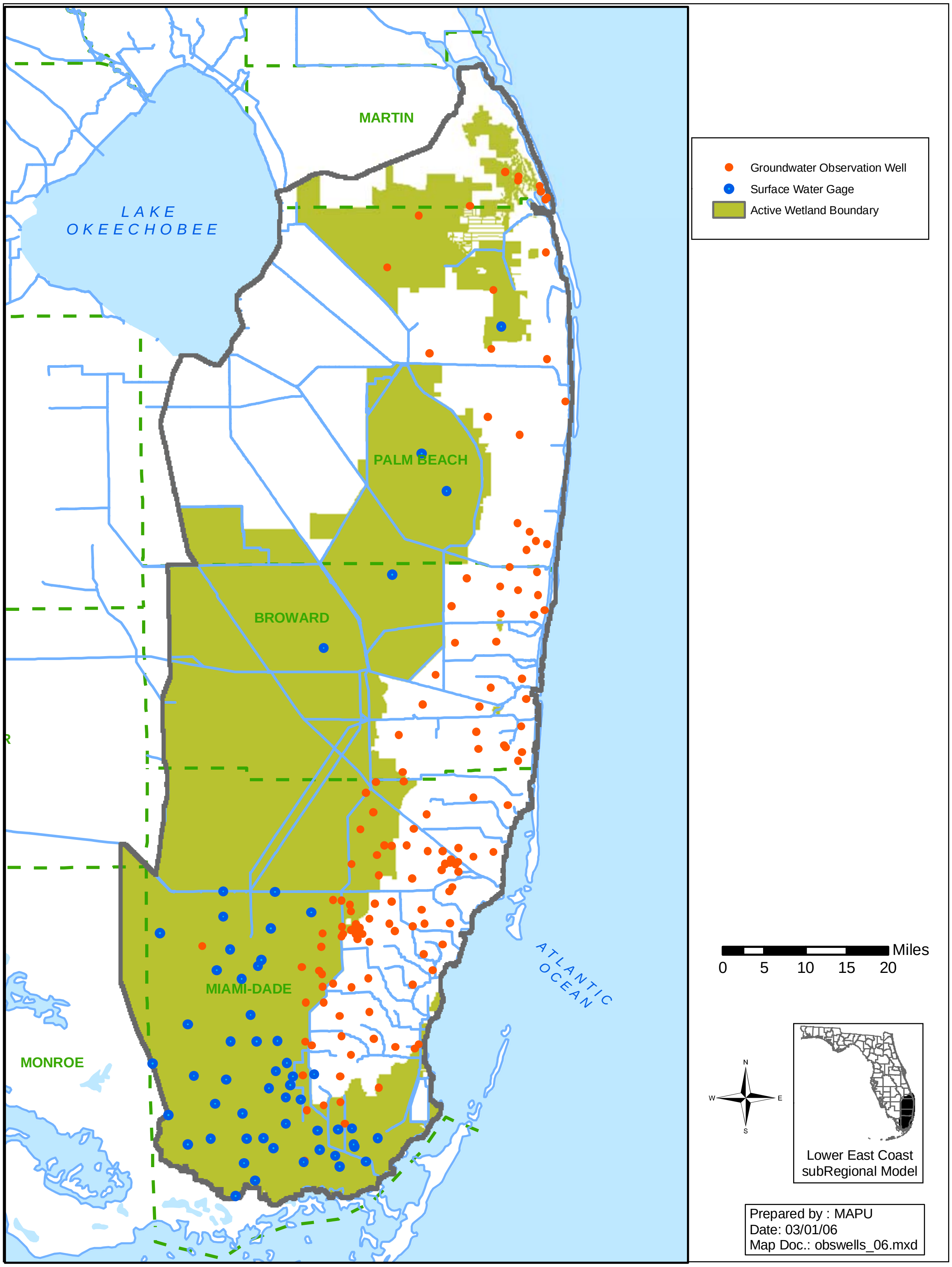
Response 200: Maps of the sediment thickness and hydraulic conductivity of the sediments may be placed in the document. A discussion of the variability observed will also be added.

Comment / Question 201: Setting the hydraulic conductivity of layer 1 to 500,000 ft/day seems extreme beyond reasonable. This rate is equivalent to 4 miles per hour. With the low relief and, therefore, flat gradient it is difficult to imagine that surface water flow could be this high.

Response 201: The 500,000 ft/day value was used only in a deep water slough in Everglades National Park. The Wetlands Package does not represent the full dynamic equation.

Comment / Question 202: Figure 78 indicates that in large areas of the model domain, particularly in the western half of the model, there are no observation wells or surface water gauges on which to base the quality of model calibration or to influence model calibration. How does the SFWMD address the non-uniform spatial distribution of model calibration target points? While the "global" criteria appear to be pretty well met, the spatial variability in target well and surface water gauge locations tends to beg the question of how well is the model really calibrated when there is fully half of the domain with no observed data on which to further judge the calibration. If the model is eventually used to address issues in these areas, will the SFWMD have the same level of confidence in the model output as in areas where the calibration was pegged to a dense spatial distribution of observed measurements? In fact, overall the model could possibly be very sub-optimum (especially in the northern half of the domain) as it appears from Figure 78 that nearly half of all calibration target wells and surface gauges are in Miami-Dade County. The model could be significantly spatially biased due to the lack of uniform spatial coverage of calibration targets. What would be the calibration results if an attempt was made to remove many of the calibration targets in the southern half of the model so that there was more uniform spatial coverage of target wells? Could the overall quality of the model be improved by this exercise?

Response 202: There are a number of additional wells that were not included in the formal calibration. These include wells that are monitored with tape downs on a monthly or quarterly basis. The quality of this data is reasonable for some wells and questionable for other wells. Inclusion of these wells would greatly increase the number of observation wells in portions of Broward, Palm Beach and Martin Counties, particularly within the urban areas. In addition several other surface water gages are available in the Water Conservation Areas which were overlooked in the original data gathering process. The District is hesitant about removing observation wells from the calibration process to attempt to achieve a more uniformed spatial coverage. The addition of these monthly or quarterly wells would be more advantageous then the remove of the wells in Miami-Dade County. However, this is a significant task and may require a fair amount of time to achieve. Regarding the EAA, we do not believe there is a single Surficial aquifer monitoring well anywhere within the area. The area is required to maintain Best Management Practices in order to minimize nutrient runoff. They comply with this by managing the water table at specific levels below ground surface. Perhaps a form of soft calibration can be utilized in this area by comparing water levels to the topography to understand the depth below ground surface and how well it compares to what the farms are operating the fields at.


MARTIN
LAKE OKEECHOBEE
PALM BEACH
BROWARD
MIAMI-DADE
MONROE
ATLANTIC OCEAN
Groundwater Observation Well
Surface Water Gage
Active Wetland Boundary
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0 5 10 15 20
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W
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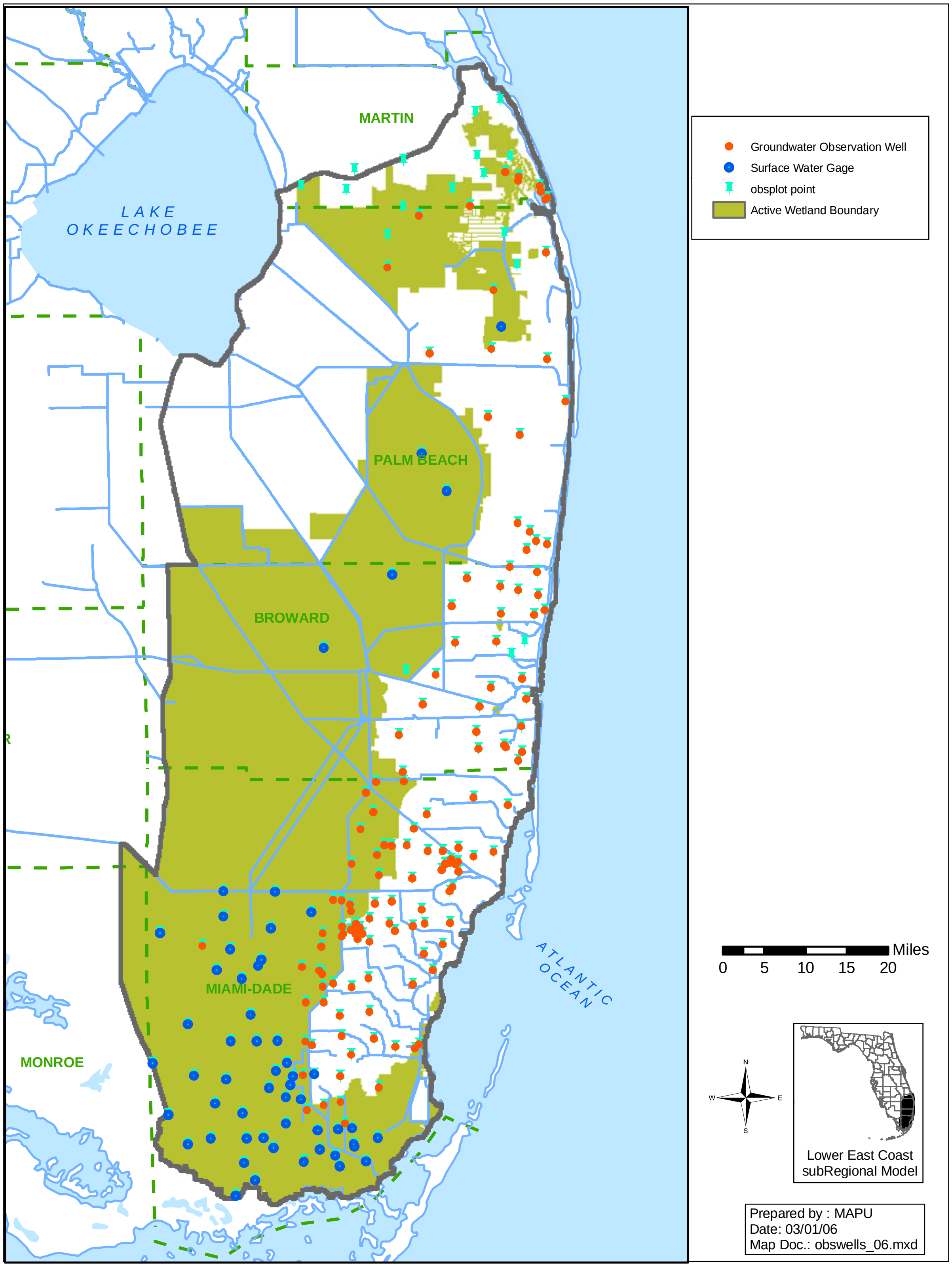
MARTIN
LAKE OKEECHOBEE
PALM BEACH
BROWARD
MIAMI-DADE
MONROE
ATLANTIC OCEAN
Groundwater Observation Well
Surface Water Gage
obsplot point
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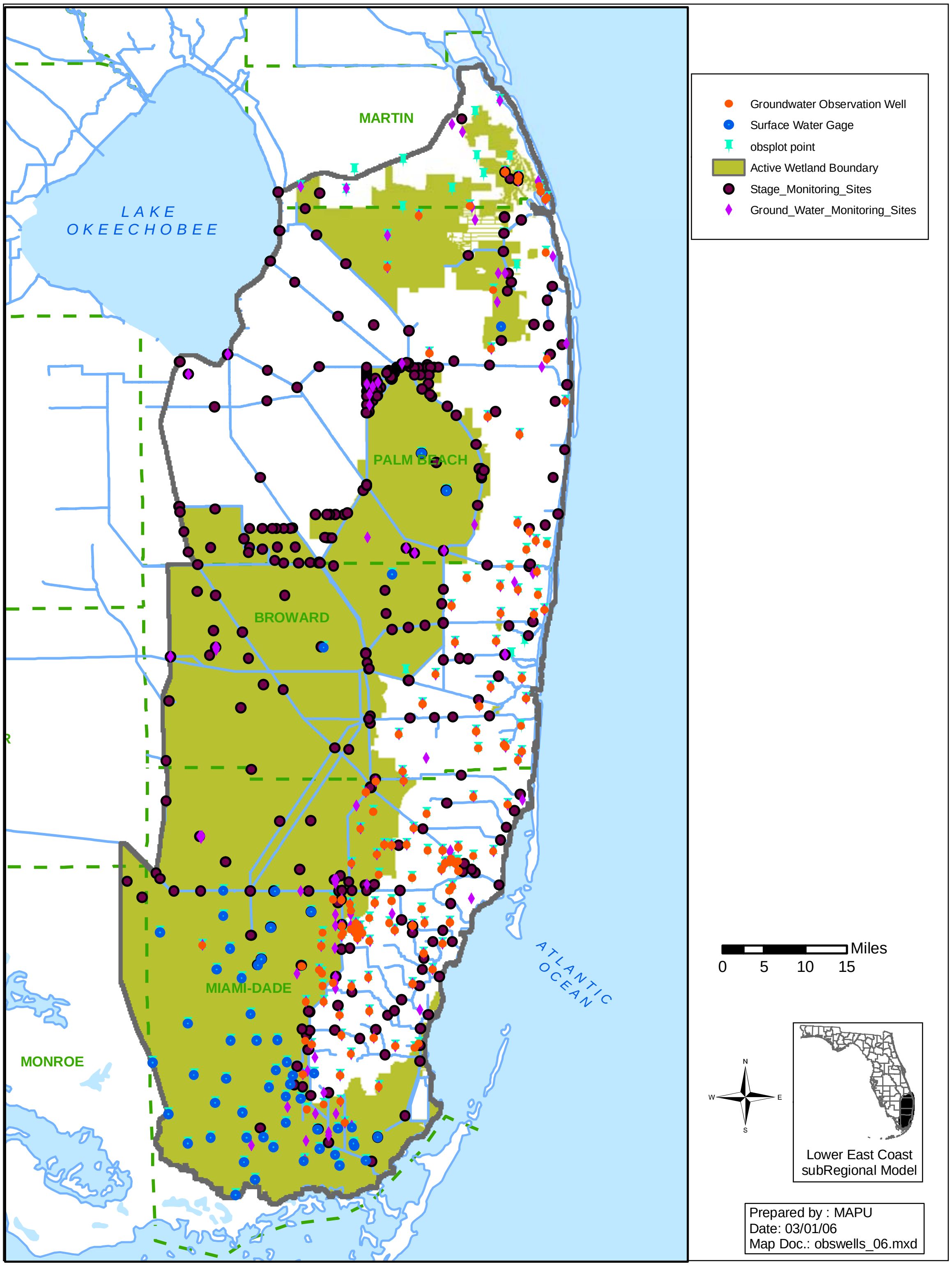
Lower East Coast subRegional Model
Prepared by : MAPU
Date: 03/01/06
Map Doc.: obswells_06.mxd



MARTIN
LAKE OKEECHOBEE
PALM BEACH
BROWARD
MIAMI-DADE
MONROE
ATLANTIC OCEAN
Groundwater Observation Well
Surface Water Gage
obsplot point
Active Wetland Boundary
Stage_Monitoring_Sites
Ground_Water_Monitoring_Sites
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Lower East Coast subRegional Model
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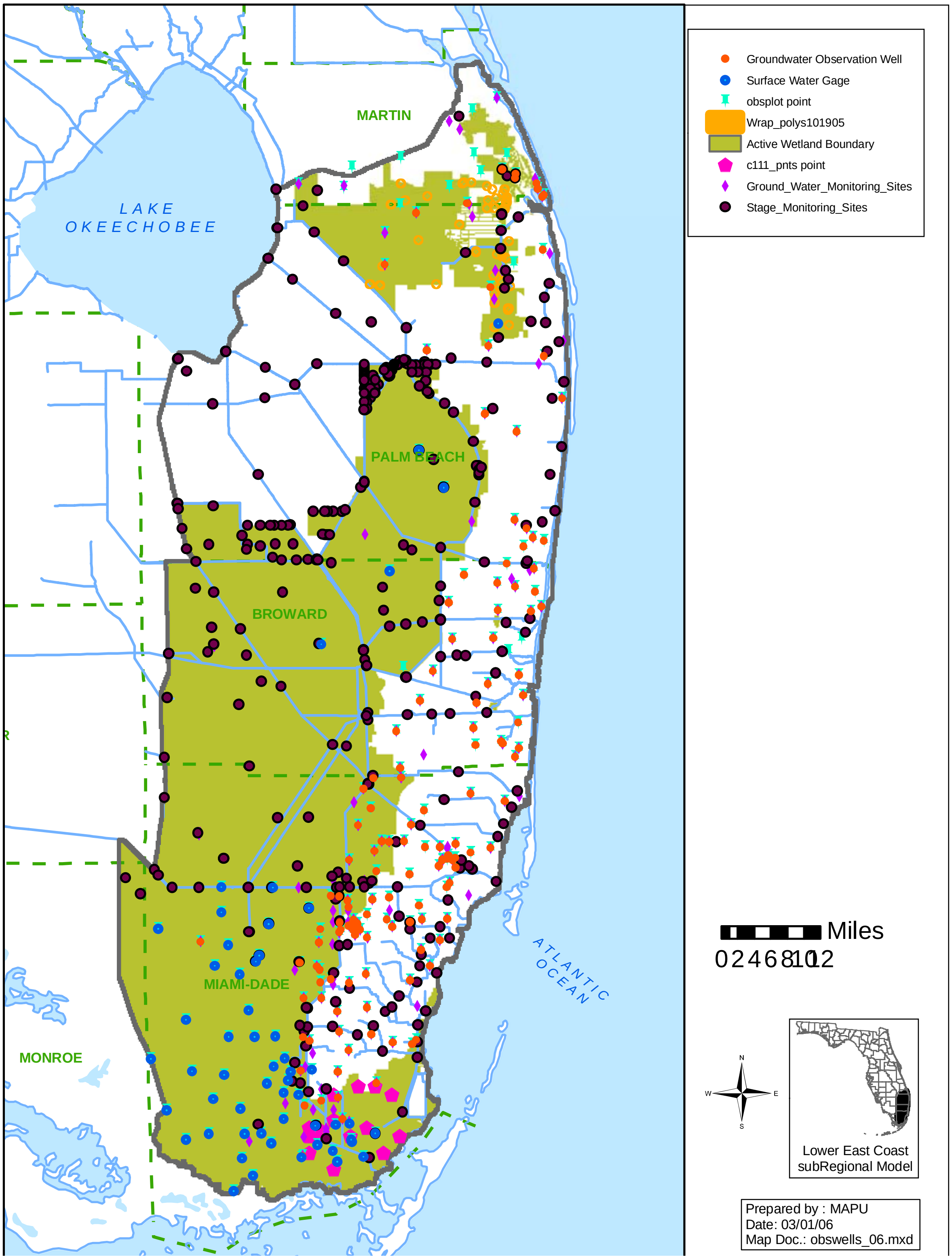
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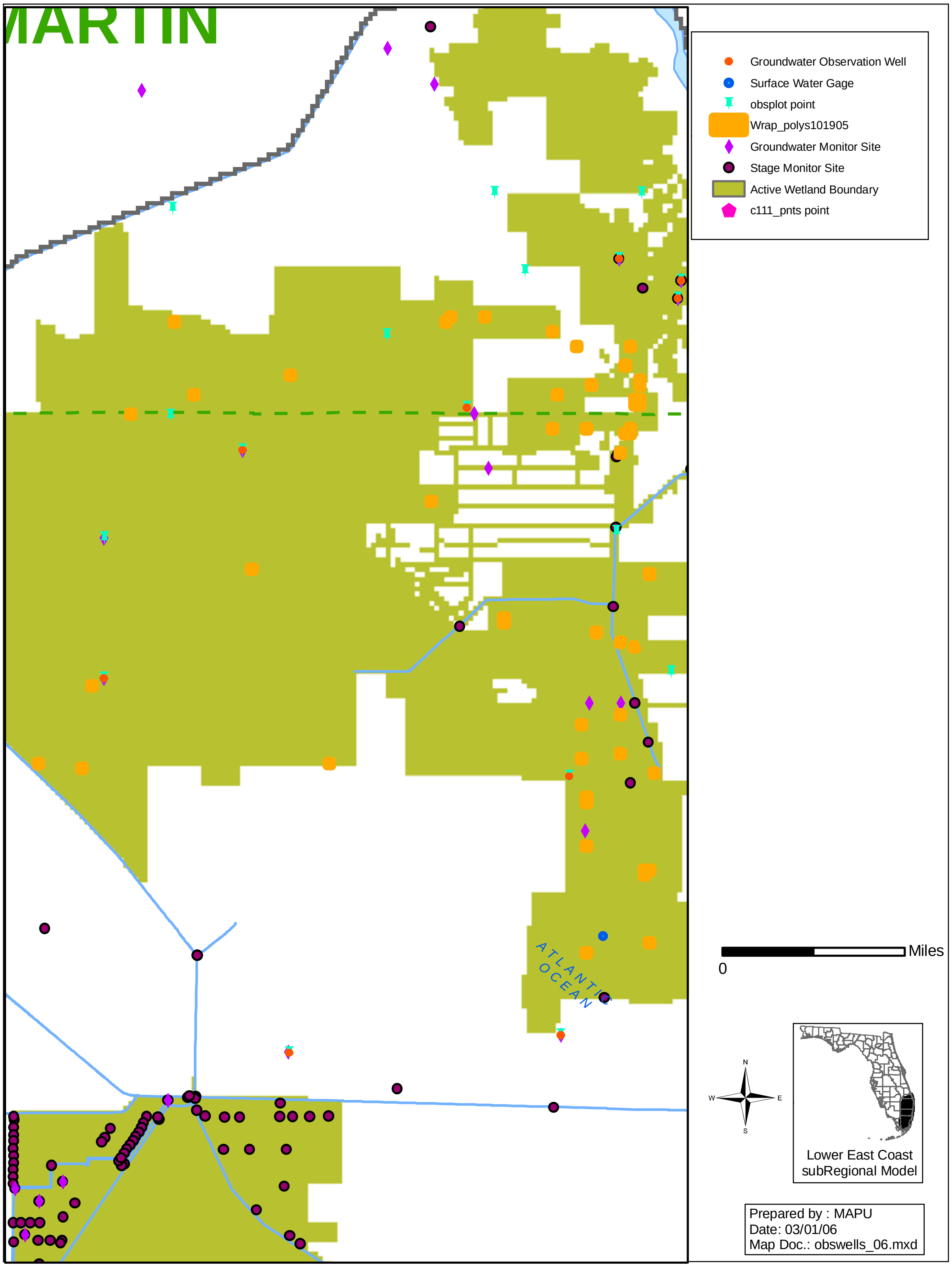
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obsplot point
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Groundwater Monitor Site
Stage Monitor Site
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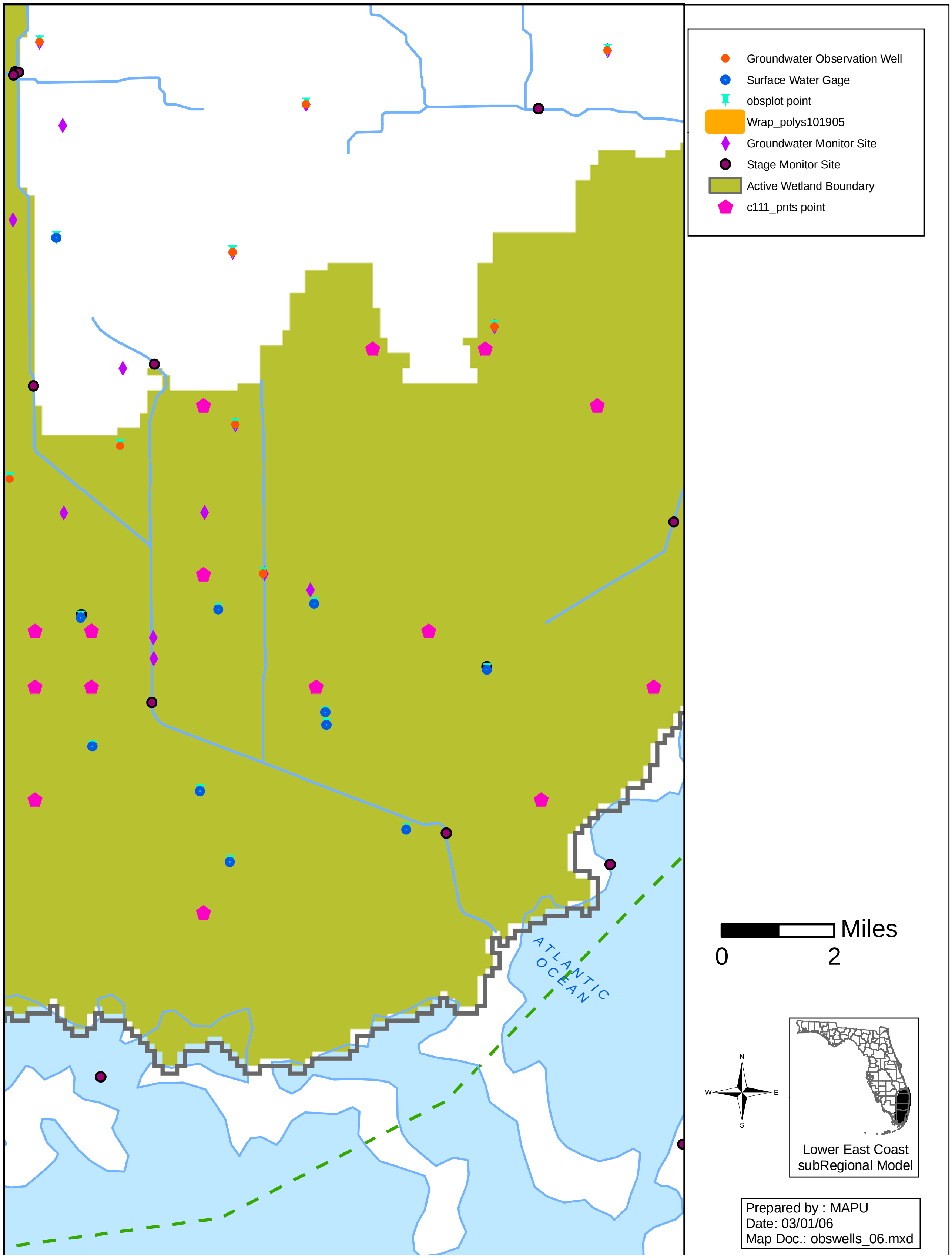

Groundwater Observation Well
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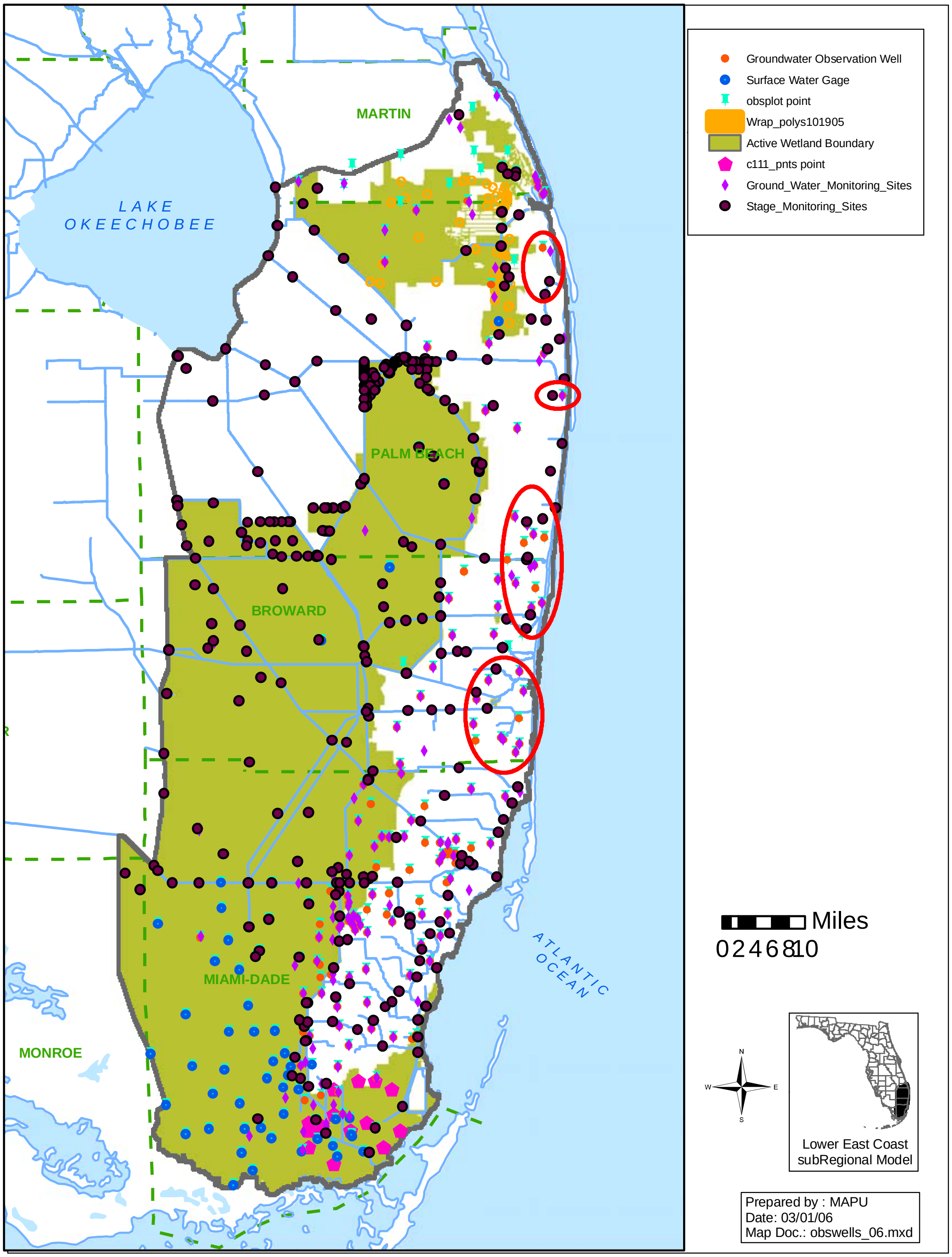


Comment / Question 203: Question 203: Please clarify what 'Simulated Range' means. Also, please clarify why the Proposed Target values of Table 10 differ from those of Table 12.

Response 203: The "Simulated Range" in Table 12 will be modified to read 'Global Model Target Achieved'. Table 12 is correct and table 10 will be modified to reflect this.

Comment / Question 204: Was there any attempt to identify what, in particular, may cause the serious departure of simulated to observed heads in a few of the wells? For example, G1074B and G2866 show significant error. Are these near well fields or some other influence that can be accounted to explain their peculiar behavior and thereby further strengthen the calibration by identifying outliers and the causes for their seemingly anomalous values? Can the prescribed (assumed) even distribution of Q throughout a well field account for some of the calibration error if, indeed, the production wells are not all pumping at the same rate and the field spans multiple grid cells?

Response 204: This is exactly correct. The majority of the wells that do not meet the calibration targets are located in the middle or immediately adjacent to a production well. The PWS withdrawals are only known on a monthly basis for the entire utility. So not only is there an unknown for the distribution of pumpage within a wellfield but also the distribution between wellfields for that utility. The District has recently recognized this and is requiring a more detailed monitoring of withdrawals from individual production wells. However, these data was not collected during the simulation period. These two particular wells are associated with two large users including Broward County Utilities and Miami-Dade Water and Sewer Authority. A discussion of this issue will be incorporated into the document.

Comment / Question 205: From Table 13 and previous text, I infer that the only quantified calibration targets for which statistics are generated are groundwater wells. Clarify whether this is correct.

Response 205: This is incorrect and the table will be modified to reflect this issue. Approximately half of the observation points are groundwater wells and the other half are surface water gages. The table will be broken out to reflect this and the graphics showing the location of the observation points will be modified to also reflect this.

Comment / Question 206: Please clarify whether the surface water gages measure head or flow. Please describe how surface water gage data are used, and where head or flow accuracy is most important. How are they used in the calibration to determine model accuracy or to generate calibration statistics?

Response 206: The surface water gages measure head. The head at the surface water gage is generally the same as the aquifer do to the unconfined nature of the aquifer system and the high transmissivity. There are several flow gages in the natural systems but no attempt was made to calibrate flow in the natural systems.

Comment / Question 207: There appears to be good agreement between observed stage and simulated stage except in a few cases. Were the major departures critically analyzed to determine what may have caused these significant simulation departures from the historical data?

Response 207: Yes, see response to question 204. The majority of the wells that do not meet calibration criteria are located in the middle and adjacent to major PWS pumping wells where little data regarding daily groundwater withdrawals are known.

Comment / Question 208: Is there a specific area that could be identified that has undergone a significant anthropogenic change that could be used to prove that the model can accurately reproduce such a change to the system? At present, it appears that the model can replicate regional changes due to climate, but can it; for example, replicate the effect of a new structure, wellfield, or operational plan?

Response 208: There are several areas that can be evaluated to address this question. In the early 1992 some canal operational changes were introduced to the C-111 basin in an attempt to provide improved hydro-periods in the area and increase flows to Florida Bay in 1997, the spoil bank on the south side of C-111 canal was removed south of S-18C. These two changes modified the hydroperiods in the region and can be noticed in well EVER3. Another area of interest occurred in the northwest wellfield of Miami-Dade County. Due to contamination of Miami-Dade's eastern wellfields, the Miami-Dade Water and Sewer Authority relied heavily upon the northwest wellfield. In the early 1990's air strippers were installed in the eastern wellfields which allowed for the utilization of these wellfields thereby reducing reliance upon the northwest wellfield. With the reduction in withdrawals from the northwest wellfield water levels responded and noticeable increases in water levels were observed at well G-3253. A similar condition occurred in Pompano Beach which involved both a reduction in wellfield withdrawals plus the introduction of wastewater reuse in lakes along the saline interface. Well G-2147 is a monitor well located immediately east of Pompano Beach's eastern wellfield. In the 1980's the eastern wellfield was used. However during 1989-90 salt water intrusion became apparent in several monitoring wells along the coast. In order to help stabilize the interface a portion of the wellfield withdrawals were increased out of the western wellfield and a series of lakes where installed east of the eastern wellfield. As a result, water levels rebounded in the eastern portions in 1990 as shown in well G-2147.

Comment / Question 209: The text states that the "volumetric budget is also a good indicator of whether the model results are reasonable." How is this assertion applied in a quantitative manner to the data presented in Table 14? How does Table 14 demonstrate that the model results are reasonable, or not reasonable?

Response 209: This section will be expanded based upon several comments received regarding the volumetric budget. The table shows that the overall mass balance of the model at the end of the simulation is less than 0.01 percent. Konikow (1978) suggested a water balance error of 0.1 percent to be acceptable while Anderson and Woessner (1992) consider 1% to be generally acceptable. However, what is missing from this section is a transient look at the budgets over time. This should provide a better understanding of the water balance on a daily stress period basis as possibly provide insight into how well the model is handling extreme events.

Comment / Question 210: The fact that the rivers are the largest sink and actually take more water than they supply is interesting. Does this observation cast any doubt on the ability to pre-specify a canal stage?

Response 210: The pre-specified canal stages are based upon historical daily data gathered both upstream and downstream of the structures and reflect any drought or rainfall conditions.

Comment / Question 211: On what basis does the SFWMD conclude that because the verification period is one-tenth the time length of the calibration period that the model appears to be robust? What us the reasoning behind doing a 1 yr verification period? In one sense, it may be a conservative choice, because it is more "event based" than a longer period. However, in another sense, is there too much history or inertia in the year following the calibration period that something is lost? For example, would the model drift if a longer period were used? Verification through 2005 seems like it would be possible, because I would think that the predictions would begin in 2006, not 2000.

Response 211: The predictive scenarios envisioned for this model, at this time, general have a year 2000 base case condition or a year 2004 base case condition. The year 2000 base case is for CERP runs and coincides with the release of the Central and South Florida comprehensive Review Study. The 2004 base case are for legal requirements for the State of Florida dealing primarily with Minimum Flows and Levels and Initial Reservations. We are presently in the process of increasing the verification period, or conducting a post audit, to bring the model up to present time. This would allow real time operations of the model which is important during times of intense rainfall during hurricane season or drought events. The late 1999-2000 period was also a period of a moderate drought event. The ability to simulate this drought period reasonable well is an important issue to the District because permits are generally issued for protection to the user of up to a 1 in 10 year drought event.

Comment / Question 212: Explain why there is significant error in those wells where it exists, by referring to Table 16 and Fig 101.

Response 212: Two of these wells were addressed in question 204. We will address the main outliers in the text

Comment / Question 213: Please define how ‘difference’ is computed.

Response 213: This is the mean absolute error for the calibration run at a well A minus the mean absolute error of the verification run at well A. This will be included in the report.

Comment / Question 214: Why wasn't the same period used for the calibration (January 1986 to September 1999) used for the sensitivity analysis instead of the shorter period January 1986 to December 1995 since the sensitivity runs are compared to the calibration results?

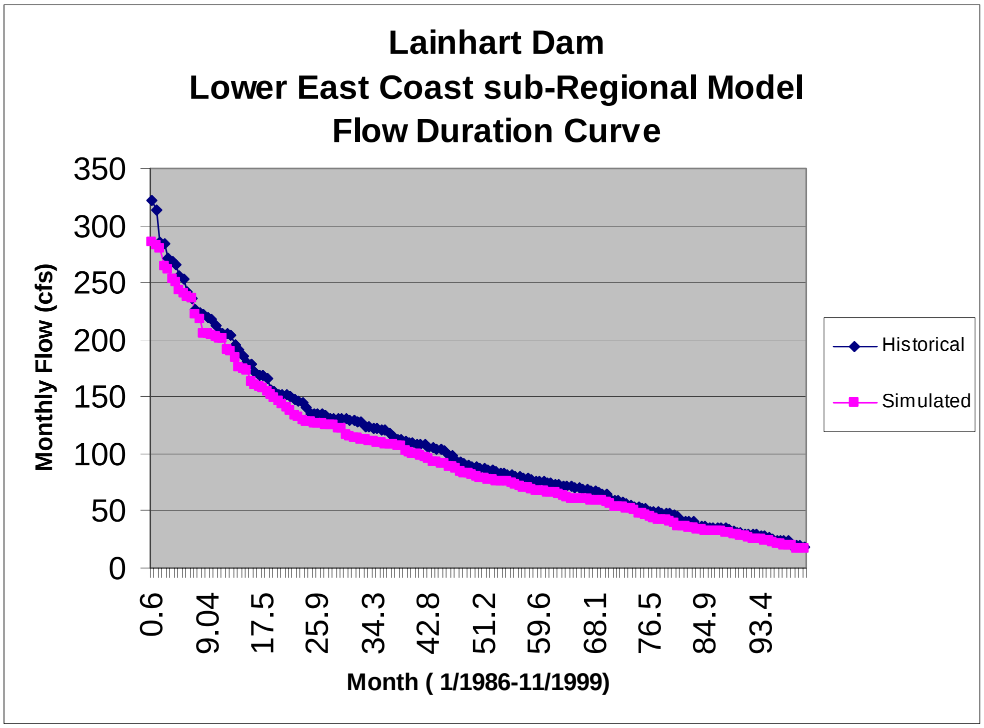
Response 214: The sensitivity runs were shorted for space and time considerations. However, care was taken in choosing the number of years for the sensitivity runs. This period of time was considered acceptable because it includes both a 1 in 100 year prolong drought (1989-1990) and a considerable wet period in 1994-1995.

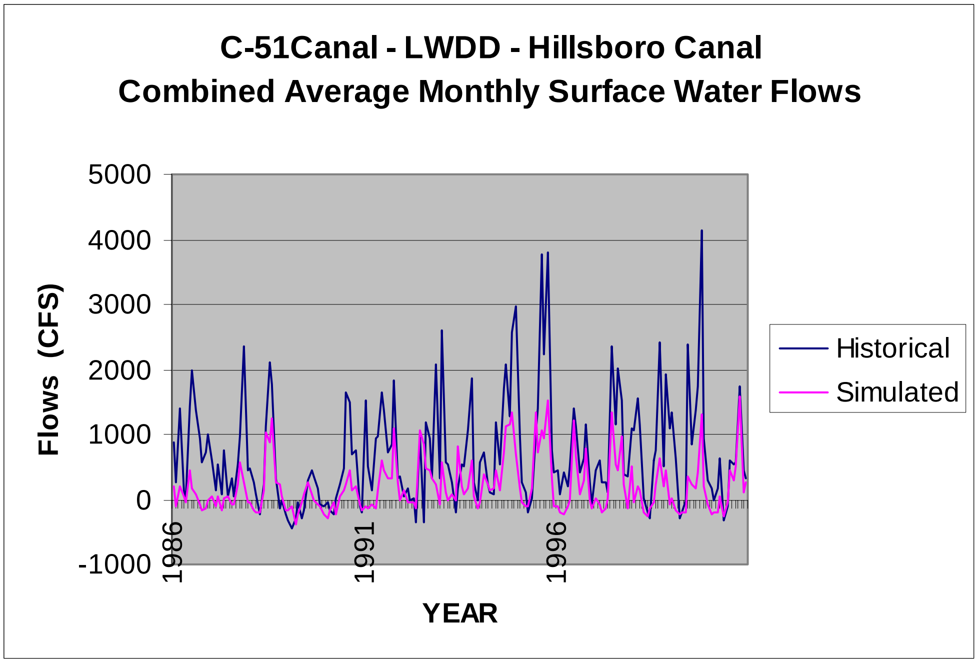
Comment / Question 215: This defines 'residuals' as the difference between simulated test head and calibrated head. Please clarify. Is (residual = test head – calibrated head) or (residual=calibrated head – test head)? Also mention that this residual is different than the Residual positive valued percentage of page 134.

Response 215: The residual = test head – calibration head. Text will be added to the document to clarify this and not to confuse it with the calibration/verification sections.

Comment / Question 216: Please report the accuracy of predicting all surface flows used in the calibration. Here, only flow in the C-18 canal is mentioned. Nowhere is found a list of all surface head and flow calibration locations. Please report all important surface flows that were not calibrated to.

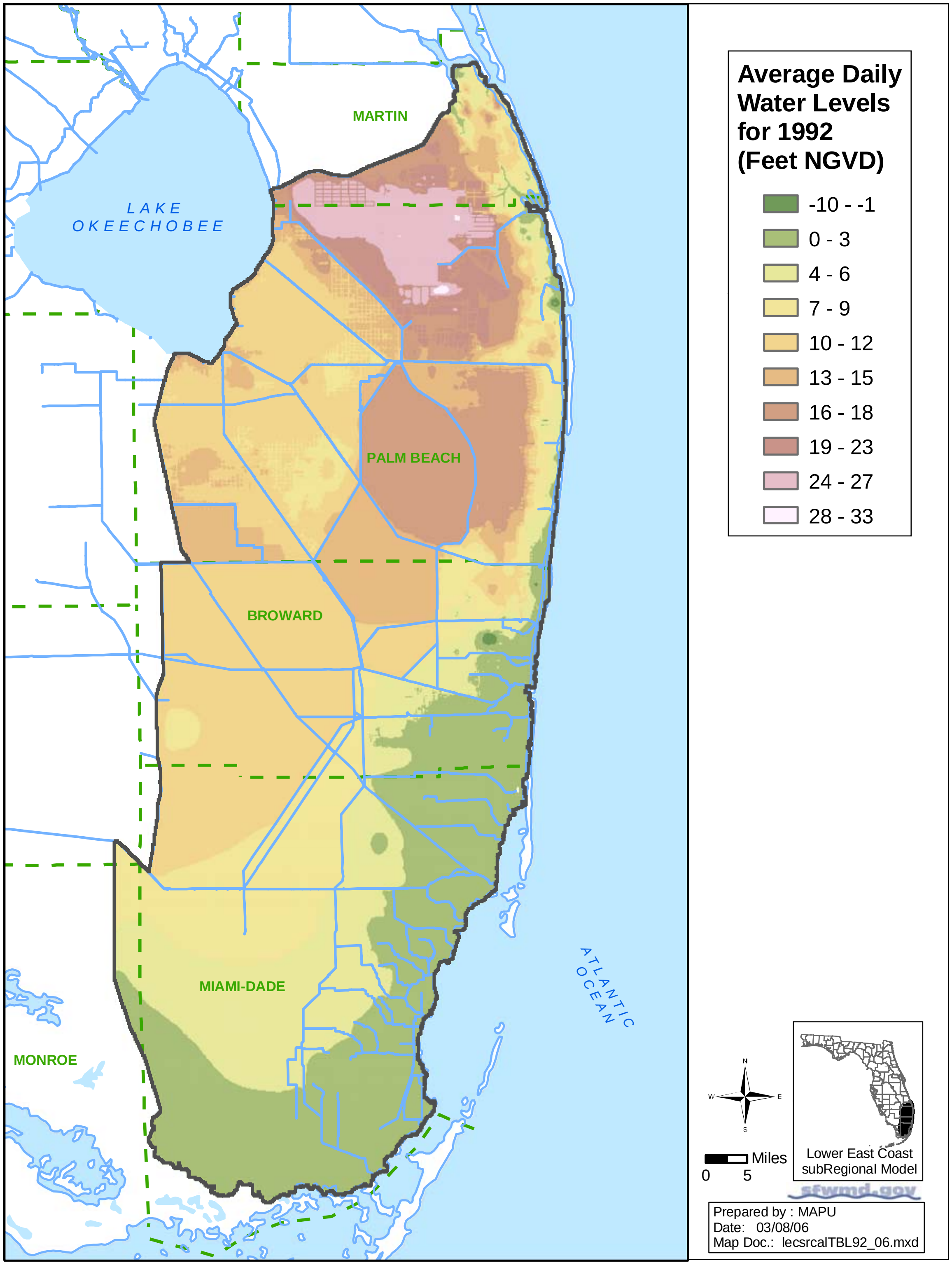
Response 216: The model will be pseudo calibrated to flows for individual sub-basins within the model domain, where data is available. The only portion of the model calibrated to flows was the C-18 basin utilizing the wetland and diversion packages. The remainder of the model utilized the standard drain and river packages. Calibration to flows in these areas may require some modifications to the preprocessing of the recharge package to fully account for flows.



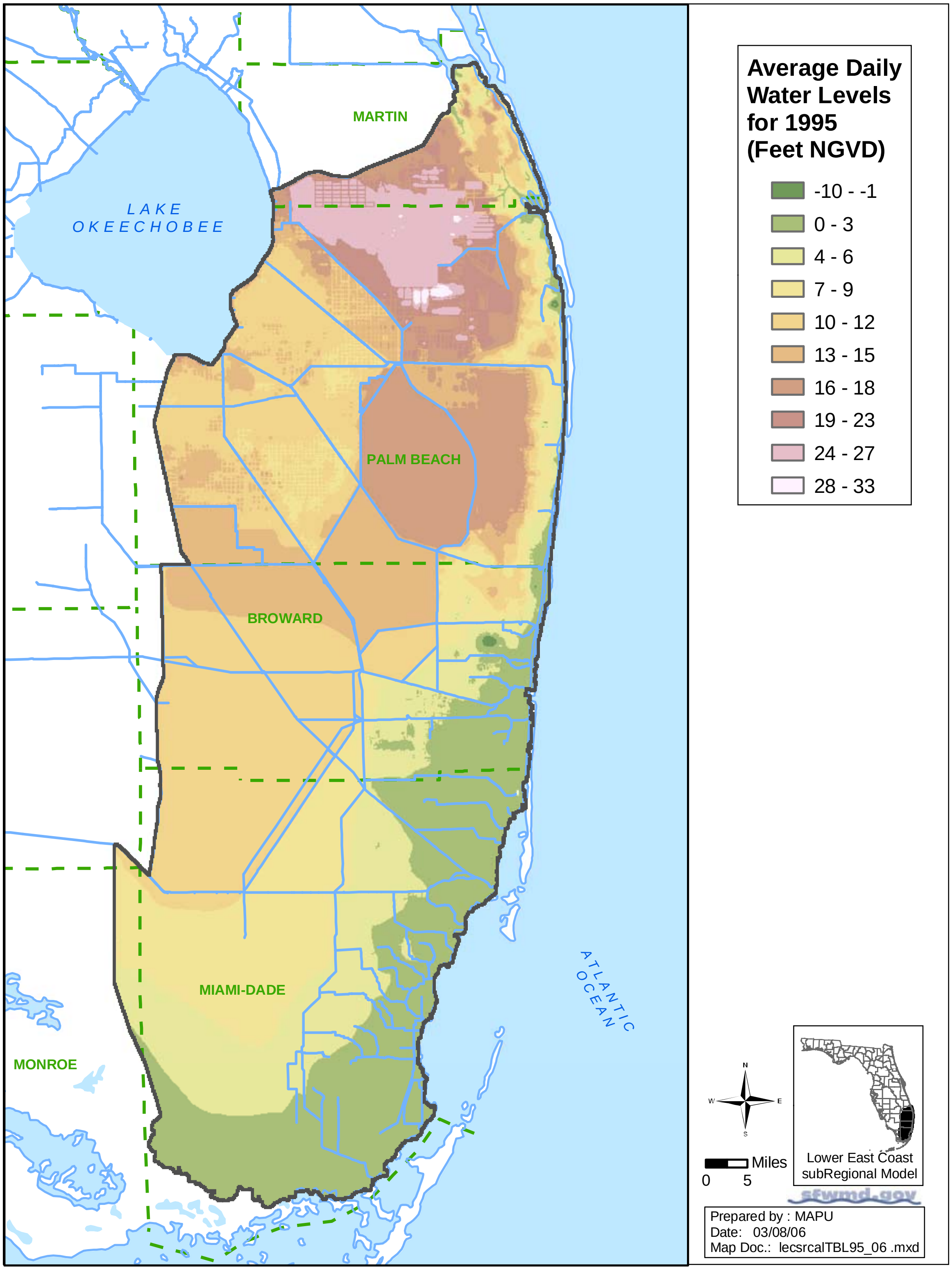


Comment / Question 217: It is stated that an intent is for the model to predict surface water flow directions properly. Provide evidence that it did so.

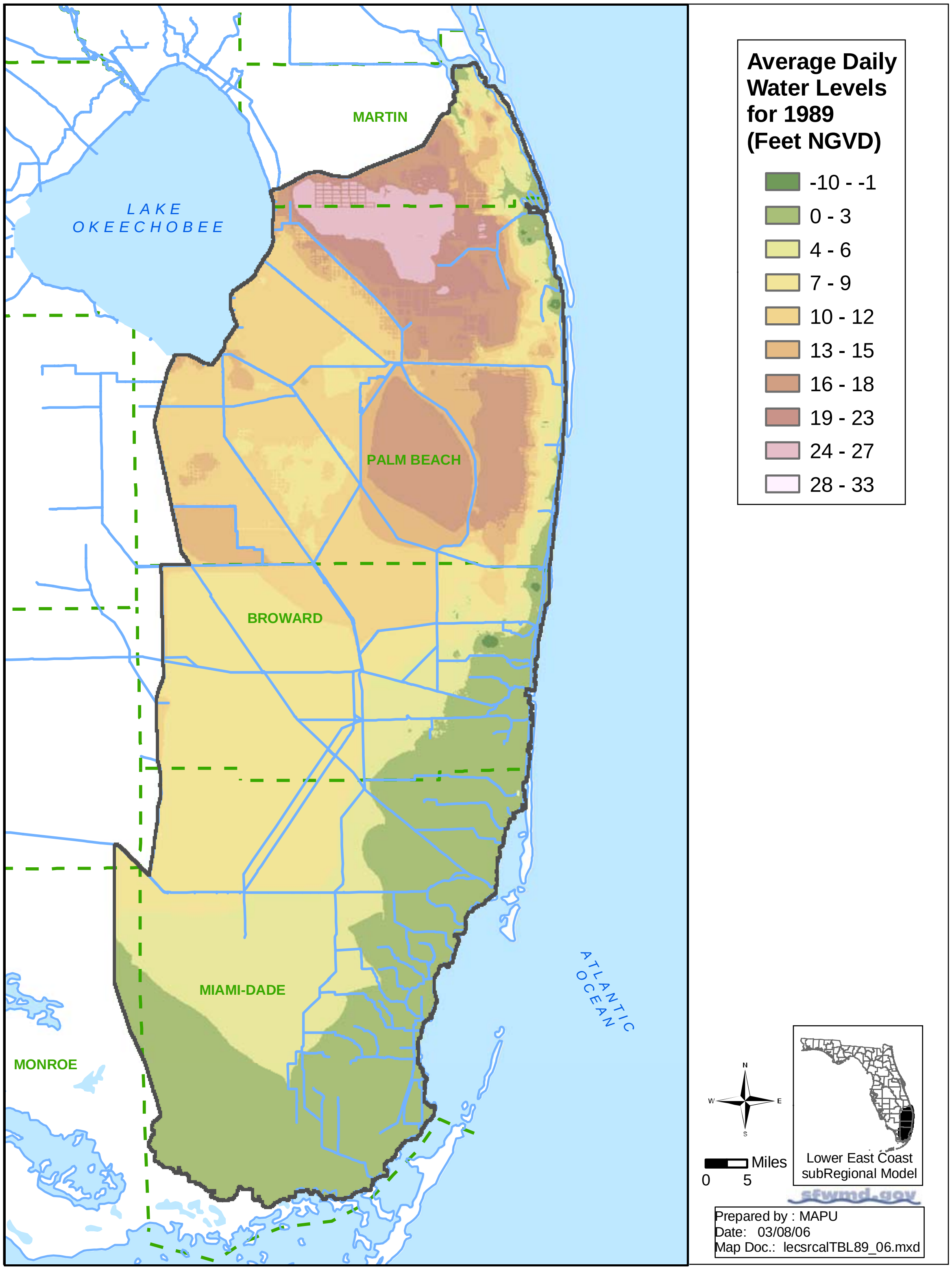
Response 217: We will provide evidence via the web board. Please see figures 83 through 85.



Average (1992) water levels(average daily water levels)



Wet (1995) water level (average daily water levels)



Dry (1989) water level (average daily water levels)

Comment / Question 218: Provide evidence of the model's accuracy in predicting the effect on aquifer head due to pumping at locations not near a fixed head boundary condition, and not in the immediate cone of depression of a pumping well (present the error as a percentage of the total observed change due to that pumping). This relates to a request to know where heads are relatively insensitive because of inputs (such as river stage).

Response 218: Please refer to Response 208.

Comment / Question 219: Provide a map showing the spatial distribution of significant head and flow prediction errors, and explain why those errors are acceptable.

Response 219: Figures 83, 84 and 85 will be modified to include the mean error for a typically average, wet and dry year. Additional text will be added to the document to discuss the results

Comment / Question 220: Were the results of the sensitivity analyses sufficient to suggest how the model could be better calibrated once the sensitivities to key parameters were determined? In other words, would another round of calibration simulations based on the knowledge gained from the sensitivity analyses improve the calibration?

Response 220: We believe this is the case and are conducting the revised calibration prior to release of the model in July. This revised calibration is designed to address the majority of the wells but to better refine the calibration particularly in the wells that have not met the target criteria.

Comment / Question 221: Once the LECsR model was completed, why weren't a series of flow path analyses performed for each layer to demonstrate the general directions of groundwater flow and relative velocities. This type analysis lends itself to qualitative model calibration and also shows the overall behavior of the simulated groundwater system.

Response 221: Flow vectors will be include in the document and discussed and included in the expansion of the soft calibration section.

Comment / Question 222: Chapter should be renamed to include Calibration, Verification, and Sensitivity Analysis

Response 222: Chapter title will be revised.

Comment / Question 223: Clarify or summarize what significant changes occurred in surface water operations in September 1999. Identify the report section at which the ramifications of these changes on the validity of the calibration will be discussed.

Response 223: The main changes in surface water operations occurred in the volume and distribution of water into Everglades National Park. A discussion of this will be included in the documentation.

Comment / Question 224: "this process was repeated multiple times by slowly decreasing the minimum and maximum tolerances…" Trying to hit a middle ground on the parameter extremes is generally not necessary in calibration unless the limits are very extreme.

Response 224: Agreed, but we feel the approach resulted in a reasonably calibrated model.

Comment / Question 225: Provide the MODFLOW convergence criteria used during simulations.

Response 225: The convergence criteria were 0.001 ft and a sensitivity analysis was conducted on this. The values ranged between 0.01 and 0.00001. A discussion will be added to the document.

Comment / Question 226: Extensive rewording is needed, including the first sentence 'The seven global model criteria should not be used to ensure a satisfactory calibration in the model." Establish or report some percentages of the time that the criteria are met, and justify when they are not satisfied. Furthermore, explain that satisfying those criteria alone would not necessarily prove satisfactory calibration. For example, they do not include surface flow rates or heads, and depth of ponded surface water in wetland areas.

Response 226: Agreed, a rewording of the paragraph with suggestions will be included.

Comment / Question 227: How many discrete simulations comprised this initial calibration exercise?

Response 227: There were approximate 15 main calibration changes with numerous other smaller runs to understand the behavior of the model to parameter changes.

Comment / Question 228: Please define quantitatively the criteria used to state whether model results are sensitive to a particular parameter value.

Response 228: This will be clarified in the text. The quantitative criteria used was if a positive change was noted in any of the for main calibration statistics for regions including a minimum of four well without having an adverse impact on surrounding wells, then it was considered as a candidate to improve the model calibration.

Comment / Question 229: Please clarify what Global Model Calibration is as opposed to other model calibration.

Response 229: The Global Model Calibration is the calibration criteria applied to all the wells as opposed to a sing well series. Because it is applying to all the wells, we would expect it to be more randomly distributed so tighter targets were employed. This will be clarified in the document.

Comment / Question 230: The specified hydraulic conductivity of 500,000 ft/d for the shark River Slough seems high. Are there other parameters that could perhaps account for the observed behavior?

Response 230: Please refer to Response 201.

Comment / Question 231: If a figure shows a 'Global' statistic, please state that in the figure title. It would be helpful to be more consistent in terminology usage.

Response 231: Changes will be made in the document.

Comment / Question 232: Clarify whether the 'three secondary calibration statistics…', refer to the 'Individual observation well criteria' of Table 10.

Response 232: The three secondary calibration criteria are included in Table 10. The table will be both reformatted and split out to allow the reader to understand which are the primary and which are the secondary calibration statistics.

Comment / Question 233: Please clarify what S2 and S4 calibration statistics are. If you want to use that terminology, include it within the new table that combines current Tables 10 and 12.

Response 233: This terminology was removed from the document but we did not catch these two. They will be change to reflect terminology utilized in the document. S2 stood for statistical criteria number 2 which is now called STD in the document.

Comment / Question 234: For all individual wells, please show, in a table, the maximum and minimum (range) of observed values, and the range of simulated values and range of differences.

Response 234: I am not sure what this gets us. The vast majority of the wells have the simulated values falling between the maximum and minimum historical values over 99 percent of the time. Suggest discussing in the text those few wells that did not perform well. However, if recommended by the Peer Review Team it will be included as a separate table.

Comment / Question 235: Show in figures the wells that have the largest positive and negative errors. Also show the localities where accuracy in prediction is most important.

Response 235: Generally speaking, everywhere in the model accuracy is important. That is because the project managers that are requesting the use of the tools have project spread throughout the model domain and have projects large enough that they could potential effect the entire area. See question 219 regarding the first part of the question.

Comment / Question 236: The "bins" in this figure don't tell much. Suggest <1.0, -0.99--0.75, -0.74--0.50, -0.49--0.25, -0.24-0.0 and positive counterparts.

Response 236: This has been modified and placed in the text.

Comment / Question 237: Clarify what model layer the target heads are in. If they are distributed through all 3 layers, please consider adding a column to show the model layer

Response 237: A column will be added to specify which layer the well is in. Also, as previously discussed, a better breakout of surface water gages versus groundwater wells will be done.

Comment / Question 238: Is there any bias or difference between calibration statistics for what are considered surface water gages and groundwater wells?

Response 238: There appears to be no significant bias between the surface water gages and the groundwater wells. However, the wells that did not meet the target have different reasons depending upon if they are wetlands or groundwater wells. Generally the wetland wells that did not meet the target are more impacted by a noticeable change in topography across one model cell were the groundwater wells that did not meet criteria are more affected by the proximity to a production well considering cell size.

Comment / Question 239: The categories suggested on the web board should be used for these figures.

Response 239: These figures have been revised accordingly.

Comment / Question 240: A similar figure should be developed for MAE to evaluate magnitude of error.

Response 240: These figures will be created.

Comment / Question 241: How can inflows to WCAs include "outflows to the urban areas"? This seems contradictory.

Response 241: In some areas where the inflow cells and outflow cells overlay a net value is used as input into the model. This will be clarified in the document.

Comment / Question 242: Figure xx is missing and is intended to show the simulated versus historical net flows for WCA 1 of Lake Okeechobee inflows minus urban outflows. This figure and other similar ones would be useful to assess the calibration. How was this used in the calibration process?

Response 242: This figure was inadvertently omitted and will be added to the document. Flows from Lake Okeechobee into the Water Catchment Areas were calibrated based upon historical data.

Comment / Question 243: Please comment on what these figures tell you.

Response 243: Comments will be added to the final documentation.

Comment / Question 244: Are flows over Lainhart Dam assumed to equate to flow in the Loxahatchee River? No hydrograph of Loxahatchee River flows is presented.

Response 244: No, total flow to the Loxahatchee River is made up of other flow terms.

Comment / Question 245: Please comment on what these figures tell you.

Response 245: Figures 91 through 94 will be discussed in more detail in the document. They most likely will be moved to a flow calibration section and include flow duration curves in the discussion.

Comment / Question 246: Are you trying to make 2 points here? Fig 98, that you don't know the exact distribution within wellfields. And Figs 99-101 that wells close to pumping wells aren't good targets?

Response 246: Correct. There are two issues here, first is when dealing with monitor wells adjacent to a major production well, a local scale model needs to be applied which includes knowing the daily distribution of pumpage for each individual production well. This is a limitation of the model due to lack of data regarding individual production well withdrawals. The text will be clarified.

Comment / Question 247: In general, it appears that the model does not hit the highs and lows (upper and lower 10 percentiles of the stage duration curves). The implication of this is perhaps that the model cannot replicate the extremes in water levels. Has sensitivity or data analysis been performed to assess the cause and significance of this? Possible causes in my view are: 1) too low a storage/specific yield, 2) monthly average modeled pumping quantities versus daily water level data.

Response 247: A sensitivity analysis will be conducted to address this issue. It is probably a combination of the monthly pumpage distribution in the model and rainfall.

Comment / Question 248: The discussion of the volumetric budget should be expanded significantly. The water budget information is at least as important as the heads. Temporal variations should be discussed.

Response 248: The volumetric budget discussion will be expanded and include temporal variations as discussed in question 209.

Comment / Question 249: Mass balance is attained for the cumulative--how is it for individual stress periods?

Response 249: The mass balance is similar between the daily stress periods and the cumulative. An improved discussion of this will be incorporated into the text.

Comment / Question 250: The relatively low well flows surprised me. Half the size of head dependent flow discharge!

Response 250: The well withdrawals are a combination of what was supplied to the District by the Utilities and what has been permitted by the District. Please not that at least 50 percent of the active model domain is wetlands and also surface water users are not incorporated into the model (with the exception of the City of West Palm Beach) which includes the entire EAA.

Comment / Question 251: The water budget implies approx 54 in yr average inflow across the model domain (from all sources: recharge, canals, etc) Does this seem high, especially since surface ET has already been taken out?

Response 251: The average annual recharge rate as shown in Figure 72, page 125, may give an indication to this. In the wetland areas, rainfall equals recharge, so with a large area of the model where this is happening recharge rates on the order of 60 inches are common. However, in the urban areas, recharge rates are on the order of 10 – 25 inches per year.

Comment / Question 252: I'm a little concerned that many of the outputs for the budget do not have calibration targets (drains, rivers). Is there any way of verifying that these numbers are reasonable?

Response 252: Please refer to Response 216.

Comment / Question 253: Text states that the verification period is 1999-2000. Table 15 states that the verification period is 1995-2000.

Response 253: The variation period is 1999-2000 and will be corrected in the Table.

Comment / Question 254: Please clarify what the verification and calibration ranges mean.

Response 254: This should read the results of the global verification run and calibration run. The table will be corrected.

Comment / Question 255: This says that Fig 100 reports the mean absolute error. However, Fig 101 says that it shows the mean error. Please correct one of them

Response 255: This is correct; Figure 100 is the mean absolute error while figure 101 is the mean error. Additional graphics will be providing similar to figure 101 which will show the aerial distribution of the mean absolute error.

Comment / Question 256: Please clarify why there are four colors of dots representing the range 1-0 feet mean error.

Response 256: This will be corrected.

Comment / Question 257: Please clarify and discuss what Table 18 means. For example, assuming that residual = test head – calibration head, lowering the ET max rate should reduce ET, increasing aquifer test head to increase, and increasing the residual—a positive change (which it does). Also decreasing the recharge rate should decrease test head, reducing the residual (which it does).

Response 257: A discussion of the results of Table 18 follows the table on pages 190 through 194. The paragraph discussion Table 18 will be improved to clarify this and present a generalize discussion on what to expect.

Comment / Question 258: Please distinguish between urban and wetland wells.

Response 258: This will be done.

Comment / Question 259: Please identify how many of the target heads are in layers 1, 2 and 3.

Response 259: This will be included.

Comment / Question 260: Please change the titles to accurately reflect what is shown, and try to use terms from Calibration Statistics, or the residual used in Table 18. A possible title for Table 19 is: 'Effect of Parameter Changes on Mean Error at Wetland Wells'—if that is what you mean by Average Head Difference. In the tables, you have defined the x axis as standard deviation of simulated minus observed values—is that correct, and if so, which of the Calibration Statistics is that related to? If none of them, please revise to use a Calibration Statistic, or a change in a Calibration Statistic, or a change in average residual as in Table 18.

Response 260: This will be corrected.

Comment / Question 261: This states that sensitivity analysis employs mean head residuals, maximum head residuals, minimum head residuals, and standard deviation of head residuals. These should be defined and mentioned along with calibration statistics in Chapter 4.

Response 261: A definition of these will be including in the prior to the discussion of Table 18.

Comment / Question 262: The LECsR model uses the wet marsh crop for PET reference but grass would be a better reference crop (page 19). Text here states that saw grass was used as the reference crop. Are saw grass and wet marsh crop synonymous?

Response 262: Yes, saw grass and wet marsh are considered synonymous and wet marsh will be utilized in the document.

Comment / Question 263: Figure 80, which is on page 150, shows only the observation network in the central model area. Text on page 133 does not reference the correct figure.

Response 263: The text will be corrected to reference figures 78 through 81.

Comment / Question 264: "…the primary indicators with STD, RES, and MIN/MAX as the secondary indicators. STD, RES, and MIN/MAX have not yet been defined

Response 264: The Chapter will be restructured so that these statistical indicators are defined in the beginning.

Comment / Question 265: The 7 criteria need to be defined better. For example what is RES or +/- 1.0 global? Looks like they are defined in the next section. Need to re-arrange.

Response 265: The chapter will be re-arranged.

Comment / Question 266: Something is missing from the sentence that ends "is independent of the variability of well."

Response 266: The sentence will be corrected.

Comment / Question 267: If this section is only on groundwater head matching, please rename the title to clarify that. Otherwise, please add important non-groundwater targets to the calibration effort. Provide criteria for evaluating surface water flow accuracy, although earlier it is stated that surface water flow prediction capability is a goal.

Response 267: The section provides calibration targets for the groundwater heads and surface water stages, but does not address flow calibration targets.

Comment / Question 268: One example of many sentences needing rewording is, "The limitation of this criteria is that it is independent of the variability of well." (Criteria is plural, criterion is singular.)

Response 268: The sentence will be corrected.

Comment / Question 269: Define the individual statistics before defining the global statistics, or better define the global statistics. Currently one has to read the individual statistic descriptions in order to understand the global statistics, yet in the text the global statistics come first

Response 269: The global statistics will be defined first.

Comment / Question 270: RMSE is the square root of the average of the squared differences in measured and simulated heads, not the average of the squared differences.

Response 270: The definition will be corrected.

Comment / Question 271: Please combine these appropriately.

Response 271: The tables will be combined.

Comment / Question 272: Please replace 'in a uniform manner' with 'in a methodical manner'.

Response 272: The words will be replaced.

Comment / Question 273: Canal hydraulic conductivity and Canal thickness of sediments are lumped into the single Conductance parameter. Thus is appears that effectively less parameters were varied in calibration.

Response 273: This is true.

Comment / Question 274: Table needs to be better formatted for clarity.

Response 274: Point taken.

Comment / Question 275: No units are listed for hydraulic conductivity estimates for the canal sediments. Ft/day is assumed.

Response 275: Units will de given.

Comment / Question 276: The two sections dealing with wetlands package parameters should be next to each other.

Response 276: We will seriously consider this comment.

Comment / Question 277: The adjustments to ET surfaces need to be quantified.

Response 277: This will be done.

Comment / Question 278: Please clarify whether this is a global statistic, and whether this shows the mean of comparisons for all target groundwater heads.

Response 278: This is a global statistic that shows the mean of comparisons for all target groundwater heads.

Comment / Question 279: Second bar from left should be labeled '0.5 to –1.0'. The end bars should indicate that they include values lower than –1.0, and greater than greater than 1.0, respectively.

Response 279: The figure will be corrected.

Comment / Question 280: Mention what the greatest differences between modeled and observed values are, both positive and negative.

Response 280: This suggestion will be included in the paragraph.

Comment / Question 281: The figure would be more easily interpreted if the color scheme was graded red to green to red for high + to zero to high - error. As it currently exists it is deceiving because -1.9 to -1.5 looks the same as -2.9 to -2.5 which isn't that much different from 1.1 to 1.5. Grading the scale will also improve the ability to identify spatial trends.

Response 281: This figure has been revised.

Comment / Question 282: What is the purpose of including these figures in the documentation when there are no corresponding calibration data included in the figures? Are these figures observed, not simulated, data? If so, they may be more appropriately located in Chapter 2 that describes the attributes of the study area.

Response 282: These figures show simulated data, which is used in the soft calibration process.

Comment / Question 283: Figure XX is not in text.

Response 283: The sentence with Figure XX was deleted.

Comment / Question 284: Vertical scale appears to be "Elevation", not "Depth". Figures are too small to be effectively viewed.

Response 284: The vertical scale is elevation. The figures will be enlarged.

Comment / Question 285: There is no discussion of the "redirected flow package" anywhere in the text to this page. There is a Diversion Package, a Reinjection Drainflow Package, and a Wetland Package. To which one does the "redirected flow package" statement refer?

Response 285: It is the Reinjection Drainflow Package – not the redirected flow package.

Comment / Question 286: It is difficult to tell where the Loxahatchee River is located in the figure. It should be bolded or shown in a different color to separate it from the other surface water features shown in the figure.

Response 286: The figure will be re-formatted.

Comment / Question 287: Please change the name so it is obvious that this figure refers to wells. Please also make it legible.

Response 287: The figure will be re-formatted.

Comment / Question 288: Needs to be re-writtern to be clearer. A better figure 93 would help, which more clearly defines the features (canals).

Response 288: MAS will review this section.

Comment / Question 289: This line was left blank in the spreadsheet submitted by the Panel.

Response 289: There is no comment, since the line was left blank.

Comment / Question 290: All three figures need to be formatted to be the same size. The presentation of the daily simulation results as mean monthly values tends to smooth the results thus obscuring potentially significant deviations of simulated values from historical values. It appears, in general, that the simulation systematically underestimates the historical mean monthly flows at these structures. This suggests that the error is not random and there may be some underlying correctable cause for the error. Or, is the underestimation an artifact of the spatial averaging due to the nature of the finite-difference grid?

Response 290: The figures will be re-formatted. The model is not capturing the peak flows.

Comment / Question 291: These figures would be more properly referred to as "Well Hydrographs" versus "Stage Hydrographs". The figures are too small to critically evaluate. If they are important to the discussion then they should be placed individually on a page and rotated 90 degrees to maximize their size. The vertical scale must be "Elevation", not "Depth", due to the negative numbers on each scale.

Response 291: The figures will be revised.

Comment / Question 292: Table needs to be better formatted for clarity.

Response 292: The table will be re-formatted.

Comment / Question 293: Please change 'run although the ' to 'run and the'

Response 293: This change will be done.

Comment / Question 294: Describe what initial conditions were used for the verification era.

Response 294: We added the verification data to the end of the calibrated model and ran from January 1, 1986 to December 31, 2000; therefore, the initial conditions from the calibrated model were used.

Comment / Question 295: Some of the circles are larger than others. Is there any significance to this? The figure would be more easily interpreted if the color scheme was graded red to green to red for high + to zero to high - error. Grading the scale will also improve the ability to identify spatial trends.

Response 295: This figure will be revised.

Comment / Question 296: Referral to ASTM (2002) is not included in "References Cited".

Response 296: This reference will be included.

Comment / Question 297: Well G2866 has a ME value of 5.32 feet, which exceeds the 3-5 ft range shown in the figure for that well. Please change the legend of Figure 101 to show that it is 3-6, or make other appropriate change.

Response 297: MAS will check the figure.

Comment / Question 298: Please mention the range of extinction depths used during calibration, especially ramifications of the + 2 feet change used in the sensitivity analysis.

Response 298: The ranges will be included in the final documentation.

Comment / Question 299: Text on page 180 states that the sensitivity results are based on 197 wells. The Table 18 caption states that the analysis is based on 193 wells. Which is correct?

Response 299: 197 wells.

Comment / Question 300: Reword sentence 2 so the meaning is clear.

Response 300: It will be re-worded.

Comment / Question 301: Please add a column to the right showing which model layers these wells are measured in (if all wells tap only layer 1, please state that).

Response 301: A column will be added.

Comment / Question 302: Please distinguish between urban and wetland wells.

Response 302: MAS will seriously consider this comment.

Comment / Question 303: Here, sensitivity analysis impacts are reported in terms of developed and wetlands areas. Cite the figure that clearly shows those areas.

Response 303: Please refer to Figures 78 to 81.

Comment / Question 304: Please clarify what initial condition information should be used to apply the model for planning purposes.

Response 304: Since the simulations start in January (dry season), an average dry steady-state solution should be used.

Chapter 5

Comment / Question 305: There should be some explanation of how the model will be used to make predictions and a general assessment of its usability in this regard. This is perhaps a more critical part of the limitations.

Response 305: A discussion will be included in the documentation

Comment / Question 306: In particular, it sounds like SFWMD will input a past climate cycle into the model to make predictive runs. This seems straightforward for precipitation and max ET. However, how will canal stages, which I assume are not totally a function of precipitation, be input?

Response 306: Canal stages for those canals which change on a daily or weekly basis for predictive scenarios are usually provide to the subregional model from the regional model. The regional model is primarily a surface water model where canal stages change in response to operations and precipitation.

Comment / Question 307: Provide guidance concerning future use. This includes acknowledging where and when error is most likely, and where results are most to be trusted.

Response 307: This will be included in the document. However, the implementation of numerous ideas and suggestions made by the peer review panel needs to be incorporated into the document and the model prior to this step.

APPENDICES

Comment / Question 308: Explain what are negative flow depths? Explain how to determine the significance of a 2 foot error.

Response 308: These are labeled incorrectly; they are elevations in NGVD 29, ft.

Comment / Question 309: Explain what seems to be a very significant error for g853. Observed were –1 depth, simulated were 3’ depth.

Response 309: This observation well is close to a major wellfield.

Comment / Question 310: Explain what seems to be a very significant error for G1074B. Observed were –10 depths, simulated were -1’ depth.

Response 310: This observation well is close to a major wellfield.

Comment / Question 311: Explain what seems to be a very significant error for G1260. Observed were 7 to -.75 feet. Predicted are 5 to 0 feet. Over 40% error.

Response 311: This observation well is close to a major wellfield.

Comment / Question 312: Title is not correct - "Hydrologic and Hydrologic Data" "hydrologic" appears twice.

Response 312: This will be corrected.

Comment / Question 313: "Table of Tables" needs to be formatted.

Response 313: This list will be formatted.

Comment / Question 314: All stage hydrographs have the vertical scale labeled "Depth" when it appears that the vertical scale is "Elevation". The same error possibly also applies to the stage duration curves.

Response 314: The y-axis should be labeled as Elevation and does apply to the stage duration curves.

Comment / Question 315: Hydrographs and Stage/Duration Curves: Is it depth or elevation? On the hydrographs, the simulated should be much more dominant and compared to the actual. The +/- 1 ft bands should be more muted. As it stands it is difficult to compare. I assume that the stage duration curves are a 1 to 1 comparison such that the percent of time equaled or exceeded is based on the period of historical data (G3567 has less points than I7)

Response 315: The Hydrographs and Stage/Duration Curves show elevation. MAS will seriously consider re-programming the graphics program according to these specifications.

Comment / Question 316: Provide a table of contents

Response 316: A table of contents will be provided.

Comment / Question 317: Please summarize results in the text. –including error as a proportion of change.

Response 317: The results from Appendix B were summarized in Chapter 4 in Table 4.

Comment / Question 318: Please state where to see the locations of structure 1-7, and other reported structure flows.

Response 318: Please refer to Chapter 4, Figures 78 to 81. 1-7 is a surface water gauge.

Comment / Question 319: Clarify the time period used to develop these plots

Response 319: These calibration plots are from January 1, 1986 through September 9, 1999. The verification plots are from September 10, 1999 through December 31, 2000.

Comment / Question 320: Explain what seems to be a very significant error for G2147.

Response 320: This observation well is close to a major wellfield.

Comment / Question 321: Explain what seems to be a very significant error for G2866.

Response 321: MAS will investigate the error and provide an explanation in the final documentation.

APPENDIX C

Panelist Answers to Topic Questions (Individual)

Andersen

Question	Response
1. Draft LECsR Documentation	
A. Does the documentation provide a clear and appropriate description of the LECR model?	YES, with clarifications noted in Chapters 2, 4 (of this review), and list of questions.
B. Are the objectives of the documentation clear?	YES
C. Are the objectives met?	YES
D. Is the documentation readable?	YES, but needs technical editing, particularly Chapters 3 and 4.
E. Are additional levels of detail required to serve the intended objectives?	YES, in some cases as noted in Chapter 4 (of this review)
F. After reading the documentation are you able to understand the purpose, scope, strengths, and limitations of the LECsR model?	YES. Some of the strengths may be inferred, although they are not explicitly addressed. Model limitations are addressed, but this section could be expanded.
G. Does the scope and format of the documentation need to be modified or expanded?	NO. However, a sections how the model will be used to make predictions should be added as noted in Chapter 4 (of this review)
2. Model Implementation	
A. Based on the documentation and presentations by the District, are the modeling techniques and methodologies used in the model appropriate for the temporal and spatial scale of the model?	YES. There are some data limitations with regard to pumping (monthly data, not categorized by individual well) that are not consistent with the fine temporal and spatial aspects of the model.
B. Is the conceptual model defensible?	YES.
C.a. Does the LECsR model include all the important physical and hydrological processes necessary to address sub-regional scale water resource issues in south Florida?	YES, representations of the relevant processes are included.
C.b Are the physical features and hydrologic processes represented adequately?	(See specific categories below)
C.b.i. Groundwater flow?	YES.
C.b.ii. Flow in and through wetland systems?	YES, on a sub-regional, but not local scale.
C.b.iii. Climatic input?	YES.
C.b.iv. Boundary Conditions?	YES.
C.b.v. Applied Stresses	YES. There are some data limitations with regard to pumping (monthly data, not categorized by individual well) that reduce accuracy over short analysis periods and near wellfields.
C.b.vi. Topography	YES. The Modeling Team appears to be aware of the different levels of accuracy that are present across the model area. The impact of this variability has not been assessed.
C.b.vii. Surface water/groundwater interaction	YES. However, the water budget with regard to groundwater seepage to/from canals was assessed only in one area in the report (and at some other areas at the request of the Panel). Documentation of the calibration of surface water/groundwater interaction needs to detailed in the model documentation.
3. Model Calibration	
A. Does the model appear to be adequately calibrated relative to other commonly employed calibration methods?	YES. Groundwater levels in wells and surface water are generally well calibrated. However, a demonstration that flows to/from canals are calibrated is needed.

Question	Response
B. Are there any other calibration criteria or methods that you recommend be used?	YES. A demonstration that flows to/from canals are calibrated is needed. Additional calibration to conditions or stresses similar to those that will be encountered in the predictions would provide confidence that the model can meet its objectives (see further discussion in Chapter 3 or this report).
C. Is additional sensitivity analysis needed for the intended purpose of the model?	NO. The sensitivity analysis performed is generally adequate. However, classification into ASTM types 1-4 would be useful to indicate limitations of predictions and as a guide to future data collection.
D. Are the verification methods appropriate?	YES. However, the verification is somewhat limited by the short period of time (1 yr) relative to the calibration period (14 yrs) and the similar climatic and stress conditions that are imposed during the verification period.
E. Does there appear to be any model bias throughout the range of model predictions?	NO, not of significance. For the calibration, there is a slight tendency to under-predict (modeled water levels lower than observed) wet season groundwater levels and over-predict (modeled water levels higher than observed) dry season groundwater levels. The magnitude of this bias is small relative to groundwater level fluctuations.
4. Overall Appropriateness of Model	
A. What are the model strengths?	Strengths of the model include: 1. the detailed physical treatment of hydrologic stresses, 2. the detailed temporal treatment of hydrologic stresses, 3. the data base upon it is built, 4. a well understood conceptual model, 5. prior knowledge from calibration of county-wide models, 6. a good calibration to groundwater and surface water levels.
B. What are the weaknesses of the model?	Weaknesses of the model include: 1. only limited event-based calibration to changes in the types of stresses to be encountered during the proposed projects has been performed. 2. the necessity to obtain boundary conditions from another model for most predictive simulations, 3. calibration to flows to/from canals has been performed only in one area in the model documentation (although Modeling Team has provided evidence to the Panel during the review) 4. there are some data limitations with regard to pumping (monthly data, not categorized by individual well) that are not consistent with the fine temporal and spatial aspects of the model. 5. the model may be too complex for application of those outside the District.
C. Are there any deficiencies of the model?	NO. However, calibration to flows to/from canals would provide greater confidence in the model.
D. Is the model suitable and defensible for the applications detailed in the documentation?	YES, based on the model calibration. However, the model's predictive accuracy has not been directly assessed. Post auditing of projects as they are developed and updating of the model are crucial to making this model an accurate predictive tool.

Peralta

Question	Response
1. Draft LECsR Documentation	
A. Does the documentation provide a clear and appropriate description of the LECR model?	YES, if clarifications requested in Panel's Written Questions and Comments, and Chapter 3 of the Panel's Panel Review are answered and addressed.
B. Are the objectives of the documentation clear?	YES
C. Are the objectives met?	YES, for the documentation
D. Is the documentation readable?	YES, but needs some editorial correction and Chapters 3 and 4 of the LECsR report need grammatical and technical editing.
E. Are additional levels of detail required to serve the intended objectives?	YES, as requested in Panel's Written Questions and Comments, and in Chapter 3 of Panel's Review
F. After reading the documentation are you able to understand the purpose, scope, strengths, and limitations of the LECsR model?	YES, after also receiving responses from Modeling Team to questions. The model is very good and powerful. Report should more clearly identify restrictions on current model use.
G. Does the scope and format of the documentation need to be modified or expanded?	LECsR report Chapter 4 (Calibration) needs significant revision, as detailed in Chapter 3 of Panel's Review.
2. Model Implementation	
A. Based on the documentation and presentations by the District, are the modeling techniques and methodologies used in the model appropriate for the temporal and spatial scale of the model?	GENERALLY YES. The Modeling Team is implementing a change to better address canals that go dry seasonally. Concur with Modeling Team recommendation to improve prediction of evapotranspiration from unsaturated zone in urban cells (hence improving recharge estimate).
B. Is the conceptual model defensible?	YES.
C.a. Does the LECsR model include all the important physical and hydrological processes necessary to address sub-regional scale water resource issues in south Florida?	YES. The report should explain hydrologic and management predictive needs for which it should and should not be applied at this time.
C.b Are the physical features and hydrologic processes represented adequately?	(See specific categories below)
C.b.i. Groundwater flow?	YES.
C.b.ii. Flow in and through wetland systems?	YES.
C.b.iii. Climatic input?	YES.
C.b.iv. Boundary Conditions?	YES.
C.b.v. Applied Stresses	YES. As mentioned above. Also, spatial and temporal distribution of pumping needs improvement.
C.b.vi. Topography	GENERALLY YES. Modeling Team is currently improving topography estimates in areas not having target heads in the current calibration.
C.b.vii. Surface water/groundwater interaction	GENERALLY YES. However, I believe that Modeling Team feels more calibration is needed to better estimate flows to coast. This might involve changing river conductance, recharge, evapotranspiration, or horizontal hydraulic conductivity.
3. Model Calibration	
A. Does the model appear to be adequately calibrated relative to other commonly employed calibration methods?	GENERALLY YES. The model predicted reasonably well for the target heads that were used, and some surface flow. Additional head or soft targets are desirable to enhance confidence in the model. For wider application, more flow calibration is needed.

Question	Response
B. Are there any other calibration criteria or methods that you recommend be used?	YES. Additional head targets or target ranges in areas currently without targets; hydroperiod targets; and canal or river flow targets, especially flow to the coast (to tide). I believe that Modeling Team feels more calibration is needed to better estimate flows to coast. This might involve changing river conductance, recharge, evapotranspiration, or horizontal hydraulic conductivity. For river conductance, Modeling Team should try to reference field work on stream depletion or seepage rates.
C. Is additional sensitivity analysis needed for the intended purpose of the model?	GENERALLY NO. However, to adequately select the most appropriate input parameters to predict canal flow (flow to tide), sensitivity analysis should be performed on parameters mentioned in C.b.vii to guide and evaluate any re-calibration. Sensitivity Analysis should be performed after any re-calibration.
D. Are the verification methods appropriate?	GENERALLY YES. However, it should be re-accomplished after any re-calibration has confirmed flow and head prediction adequacy using existing and new targets.
E. Does there appear to be any model bias throughout the range of model predictions?	NO SIGNIFICANT BIAS.
4. Overall Appropriateness of Model	
A. What are the model strengths?	Strengths of the model include: 1. huge data base that is becoming ever better organized. 2. ability to rapidly modify code and develop data to improve predictive capability. 3. wonderfully detailed representation of hydrologic phenomenon and distribution system water balances. 4. characterization that is in harmony with the conceptual model.
B. What are the weaknesses of the model?	1. Limitations being addressed by Modeling Team, including: inaccurate spatial and temporal distribution of groundwater pumping for public supply; lack of target heads in EAA and some other areas; lack of flow and soft calibration targets. 2. Challenges in confirming surface water-aquifer seepage rates, & surface water flow rates, especially to tide. 3. Need for more documentation in predicting hydroperiods (a two month hydroperiod could be missed by a model that satisfies head calibration criteria). 4. Per Modeling Team recommendation, in developed areas, evapotranspiration from unsaturated zone and recharge should be computed while model is iterating, rather than in pre-processor. However, unknown impact varies with location.
C. Are there any deficiencies of the model?	Only those Modeling Team will probably address. (see B above.)
D. Is the model suitable and defensible for the applications detailed in the documentation?	FOR MOST. Suitable for predicting heads near targets, and some surface flows. Unsure how well it predicts: some hydroperiods, heads away from targets, surface flows not reported in calibration. With additional work the model can be appropriate for all the above

Shafer

Question	Response
1. Draft LECsR Documentation	
A. Does the documentation provide a clear and appropriate description of the LECR model?	YES, The documentation provides a clear and appropriate description of the LECsR model for the most part. As pointed out during the review process there are some sections of the documentation that need to be enhanced with either a key figure or two and/or additional text.
B. Are the objectives of the documentation clear?	YES, The objectives of the documentation are reasonably clear. The Introduction describes the overall purpose of the documentation and the content of each chapter in the documentation, as well.
C. Are the objectives met?	YES, The objectives of the documentation, as outlined in the Introduction, are met.
D. Is the documentation readable?	There are very many typographical and grammatical errors throughout the documentation that should be resolved to improve it readability. The figures are mis-numbered and in some cases need improvements made to the legends to increase the understanding of those figures. These suggestions are noted in the marked up copy to be provided the Modeling Team.
E. Are additional levels of detail required to serve the intended objectives?	Additional levels of detail are required for certain topics which received focus during the review and for which specific suggestions were made. For example, the discussion of soft calibration targets needs additional attention.
F. After reading the documentation are you able to understand the purpose, scope, strengths, and limitations of the LECsR model?	YES, The purpose, scope, strengths, and limitations of the LECsR model are understandable from the documentation.
G. Does the scope and format of the documentation need to be modified or expanded?	The overall scope and the format of the documentation are acceptable.
2. Model Implementation	
A. Based on the documentation and presentations by the District, are the modeling techniques and methodologies used in the model appropriate for the temporal and spatial scale of the model?	GENERALLY YES The modeling techniques and methodologies used in the LECsR model are appropriate for the temporal and spatial scale of the model. However, there are more sophisticated spatial interpretation methodologies that may be used in future versions of the model.
B. Is the conceptual model defensible?	YES.
C.a. Does the LECsR model include all the important physical and hydrological processes necessary to address sub-regional scale water resource issues in south Florida?	YES. The LECsR model includes all the important physical and hydrologic processes necessary to address subregional-scale water resource issues within the model domain (as opposed to South Florida, in general).
C.b Are the physical features and hydrologic processes represented adequately?	(See specific categories below)
C.b.i. Groundwater flow?	Groundwater flow is the dominant process of the model. Based on calibration and flow path representation, the LECsR model appears to adequately simulate groundwater flow.
C.b.ii. Flow in and through wetland systems?	Flow in and through the wetland system is simulated using a custom developed add-on package to MODFLOW for the specific purpose of addressing flow in and through the wetland system. This package adequately simulates wetland system processes.
C.b.iii. Climatic input?	All relevant climatic inputs (e.g., precipitation) are included in the model.

Question	Response
C.b.iv. Boundary Conditions?	External boundary conditions are all naturally occurring boundaries. Internal boundary conditions reflect the groundwater – surface water conditions present within the model domain..
C.b.v. Applied Stresses	The applied stresses (e.g., precipitation, pumping, etc.) are realistic and representative of the conditions present throughout the calibration period. There are some inherent temporal inconsistencies such as weekly or monthly data versus daily data that the Modeling Team reconciled.
C.b.vi. Topography	Due to the low relief within the model domain and the associated importance of accurate land surface control, the Modeling Team used all available data (from a variety of sources) to develop the most accurate surface topography reasonably possible for the LECsR model.
C.b.vii. Surface water/groundwater interaction	Groundwater – surface water interaction (i.e., connections) is a critical aspect of the LECsR model. All significant surface water conveyance and wetland features within the model domain are appropriately simulated. Several recommendations were made that the Modeling Team adopted that improve some aspects of the simulation of groundwater – surface water interaction.
3. Model Calibration	
A. Does the model appear to be adequately calibrated relative to other commonly employed calibration methods?	The approach to LECsR model calibration followed standard groundwater modeling practice. The model calibration criteria are acceptable.
B. Are there any other calibration criteria or methods that you recommend be used?	The Modeling Team is adding soft calibration targets such as aperiodically observed heads in wells not included in the original set of calibration wells and other anecdotal information that demonstrates the accuracy of the model in geographic locations where hard calibration targets are sparse.
C. Is additional sensitivity analysis needed for the intended purpose of the model?	No additional sensitivity analysis is required for the intended purpose of the LECsR model.
D. Are the verification methods appropriate?	The model verification method is appropriate. However, a longer simulation period for verification may have exposed the model to more extreme variability in stresses which would better reveal the overall robustness of the model.
E. Does there appear to be any model bias throughout the range of model predictions?	In general, there appears to be no significant bias in the model simulation. The model does not simulate extreme conditions as well as more normal conditions. However, this may be the inevitable result of the inherent spatial averaging process of the finite difference modeling approach.
4. Overall Appropriateness of Model	
A. What are the model strengths?	The LECsR model strengths are numerous. First, it is a comprehensive model of the Surficial Aquifer System incorporating the important hydrostratigraphic units and the groundwater – surface water connections within the model domain. Second, the model is based on “real” data to the extent real data are available for the various components of the model. Third, the LECsR model has high spatial and temporal resolution. Fourth, the model is reasonably well-calibrated to observed well hydrographs and surface water stages. Five, there is significant collective expertise involved in the model development and its application.

Question	Response
B. What are the weaknesses of the model?	A weakness in the model may be the possible spatial bias in calibration that is being addressed, in large part, by inclusion of soft calibration targets (such as heads in wells that are observed aperiodically) and other anecdotal information.
C. Are there any deficiencies of the model?	There are no significant deficiencies in the model. In future versions of the model, a more sophisticated approach than that currently used could be employed to develop spatial distributions of parameters such as hydraulic conductivity.
D. Is the model suitable and defensible for the applications detailed in the documentation?	The LECsR model is suitable and defensible for addressing subregional-scale water resources issues pertaining to the surficial aquifer system and surface water interactions within the model domain.

APPENDIX D
Scope of Work

WATER SUPPLY DEPARTMENT

STATEMENT OF WORK (SOW) FOR PEER REVIEW

OF THE LOWER EAST COAST SUBREGIONAL MODFLOW MODEL AND MODEL DOCUMENTATION

Requesting Professional: Hope Radin, Staff Hydrogeologist

Requesting Division: Resource Evaluation and Subregional Modeling Division, Water Supply Department

Project Name: Peer Review of the Lower East Coast Subregional MODFLOW Model

Date: January 31, 2006

Introduction

The request for Peer Review pertains to the recently implemented Lower East Coast Subregional MODFLOW Model (LECsR model). The LECsR model is a subregional groundwater flow model with surface water capabilities, which represents the Surficial Aquifer System (SAS) in south Florida and covers roughly 7,500 square miles. The LECsR model is underlain by two aquifer systems: the SAS and the deeper Floridan Aquifer System. This study focuses on the SAS and encompasses nearly the entire system within the study area.

Hydrologic models are used at the District for water supply planning, design evaluation, water resource rulemaking, and water use permitting. After model development, the models are applied to various planning and management scenarios. A model should be a reliable tool for the prediction of water level changes over a wide range of hydrologic conditions. When the models are used for planning, rulemaking and permitting, new pumpage data sets are developed that represent currently allocated water, requested new allocations or projected future demands. In addition, changes to the stages in the wetlands or the groundwater levels at the boundaries may be made to take into account the proposed water supply improvements. The climatic conditions (recharge, evapotranspiration) and hydrologic conditions (changes in canal stages) represented in planning and regulatory simulations may differ considerably from those present in the calibration period of record.

Peer Review

Purpose

The purpose of the peer review is to evaluate the following:

Model objectives, conceptualization, design, and assumptions made for input data sets.

Model documentation (explanation of model, data sources and assumptions).

Suitability of model for its intended applications.

The District Peer Review intent is to ensure that the LECsR model was developed and implemented based on sound science and modeling principles. The review process shall include participation as a Panelist in workshops, teleconferences and submitting written Peer Review Reports. The Panel shall submit a comprehensive Peer Review Report with their conclusions on the strengths and weaknesses of the model.

The predicted impacts and other information derived from models can influence major investment decisions. Those who use the model results must have some indication as to their reliability. Users of the model and its documentation should be assured that the information contained in them is credible and unbiased, that the assumptions applied are reasonable, and that the results are reported fully and accurately.

Users of any model should be aware of the types of analyses for which the model is best suited and those for which the model is not well suited. The LECsR model Document (Giddings et al 2006), along with the results of a Peer Review of any model application, should help the potential model user better understand the limitations and the best uses of the model output.

Panelist Requirements and Expertise

It is imperative that each Panelist shall have the following skills:

Expertise in applied groundwater modeling, combined with a strong background in hydrogeology, surface water hydrology and water resource evaluation. Extensive experience in the development and subsequent application of the finite difference model MODFLOW preferred.

Comprehensive experience in model development, implementation, and application of hydrologic and hydraulic models, and integrated modeling systems.

Effective communication skills, particularly good writing skills.

Available to dedicate significant review effort during the peer review period.

Available to participate in workshops, (dates to be set prior to execution of purchase order) and teleconference meetings.

Ability to conduct an objective and independent review.

Panelist shall be free of any real or perceived conflict of interest, including recent modeling work for the District or for any organization involved in hydrologic or water management modeling in south Florida.

For the Chairperson, excellent communication skills are required, particularly excellent writing skills. Experience chairing Peer Review Panels and consolidating comments from multiple Panelists preferred.

It is preferred, but not required, that each Panelist shall have the following additional skills:

Expertise in complex surface-water/groundwater interactions

Demonstrated ability to understand the potential impacts to the south Florida region from simulated changes in hydrologic conditions, operational guidelines, and management objectives.

Application of subregional models for resolving real-world problems in water resource management, including environmental restoration, water supply, flood control, or drought management.

Guidelines for Peer Review

Candidates must have appropriate experience as noted in Section 2.2. All Panelists will receive payment for their participation on the Panel. One Panelist will be selected as the Chairperson, to be a single point of contact between the District and the Panel. The Chairperson shall have additional duties and will receive payment accordingly based on an estimate of additional hours to be worked. The Panel as a group shall evaluate the entire model, but the Chairperson may delegate individual Panelists to be the lead on subject matters in which they specialize.

As shown in Table 1 (Time Line and responsibilities), all Panelists shall attend a one day kick off meeting and an additional one-day on-site workshop in West Palm Beach, Florida. Workshops dates will be finalized prior to execution of purchase order (P.O.). The workshops will help the Panelists gain a better understanding of the LECsR model, and its existing applications. It is expected that once individuals have been selected and have accepted their position, they shall begin studying the Draft LECsR model Documentation and background materials to prepare them for the workshop. All Panelists should be prepared to take notes and ask questions about the model. The workshops are a venue for panelists to work face to face with each other and staff and clarify any items that were not clarified during teleconferences.

The District has organized the Peer Review process in accordance with accepted scientific review practices. Care will be taken in selecting the Panelists to assure that Panelists are independent of the District. Panelists should have no substantial personal or professional relationship with the District or any other organization involved in environmental management in south Florida. The Panel can therefore be reasonably assumed to be objective in evaluating materials presented in the model and documentation. Such objectivity is the cornerstone of any true Peer Review process.

Panel review, as opposed to review by individual experts, is done by a group which reviews the LECsR model and documentation independently and then interacts with one another to formulate opinions on the state of the model. The Panel shall collaborate on recommendations and proposed changes to the LECsR model and/or documentation. Based on this collaboration, a Draft Peer Review Report to the District shall be prepared so that the District staff can respond and comment on the Panel's findings. The Chairperson shall then write a Final Peer Review Report incorporating District responses and the Panel's final conclusions.

The Peer Review Panel Web Board shall be used by the Panelists to post questions to District staff and to post their work in progress. This Web Board will be conducted in accordance with Florida 'government in the sunshine' statutes. Panelists are required to read the information on the sunshine laws at http://www.sfwmd.gov/org/erd/Web Board/sunshine.html#sunshine. Panelists may post materials, but may not respond to or have discussions with other members of the Panel or have discussions via a liaison. District staff will provide a set of instructions for using the Web Board as an attachment to this SOW. The public can stay informed by reviewing the Web Board on the District web site at http://Web Board.sfwmd.gov:8080/~gwpeerreview. The public can post comments and monitor the progress of the review.

The Web Board serves as a repository to allow Panelists to submit their comments on the documentation and to distribute documents such as the Draft and Final Peer Review Reports. It also allows the District to disseminate information about this review, and it allows the general public to closely follow the development of the review. Discussions among Panelists relating to this Peer Review shall occur only during the public workshop and at predetermined, posted teleconferences .

Summary of Time Line and Responsibilities

Table 1: Time Line and Responsibilities

Task/Action	Responsible Party	Deliverable & Due Date*
Execution of Purchase Order	Procurement	On or before March 1
Send Background Materials to Panelists	District	Within 2 days of execution of P.O. March 3
Task 1A: Acknowledgement of Materials	Panelist	Within 2 days of receiving materials - (~ 1 week from purchase order execution) (March 13th)
Task 1B Active Participation in kick off meeting.	Kick off Meeting	March 13th
Task 2A Comments and questions submitted to Chairperson Task 2B Compiled set of questions and submit to the District	Panelist Chairperson	March 20th March 23
Task 3A.1 Draft Agenda Final workshop agenda	Chairperson District	March 23 March 31
Task 3A.2 Active Participation in workshop	All Panelists and Chairperson	Attend all portions of workshop. April 4
Task 3B Active Participation in teleconferences (Weeks 3	District will set dates and time. All Panelists and Chairperson	Attend teleconferences as scheduled. (Weekly teleconferences will be setup by District)

		Chairperson shall post agenda at least one business day prior to teleconference.
Task 4. Draft Peer Review Report	Panelist report to Chairperson Chairperson report to District	April 26 May 3
District review	District comments to Chairperson	May 19
Task 5 Final Peer Review Report	Panelist report to Chairperson Chairperson report to District	May 30 June 2

* Date from the PO execution. Dates will be modified base on p.o. execution date but June 2 final date can not be changed.

Scope of Work

Duties and Tasks of Panel and Chairperson

During this project the Panelists shall complete all of the assigned tasks that are listed below. The District has assigned one Panelist to be the Chairperson for the Panel. In addition to the tasks that are to be completed by all the Panelists, the Chairperson shall have extra tasks and responsibilities.

Duties for all Panelists include:

Conducting preliminary review of the LECsR model based on the Draft LECsR model Documentation provided by the District. (Review shall investigate model objectives, model conceptualization, model design and assumptions made for input data sets)

Reviewing and evaluating model documentation (e.g., explanation of model, data sources and assumptions)

Submitting questions and comments to the District prior to the second workshop.

Reviewing and evaluating the model's suitability for its intended application.

Actively participating in workshops and teleconferences.

Responding to topic questions listed in 4.1.2.1 below.

Contributing to the Draft Peer Review Report.

Contributing to the Final Peer Review Report.

In addition to the Panelist duties described above the Chairperson shall also perform the following duties:

Submit draft workshop agenda (for second workshop).

Submit agendas for teleconferences.

Assign tasks to Panelists and ensure that they fully understand the requirements for each task.

Organize materials from other Panelists and submit Draft Peer Review Report and Final Peer Review Report.

The Chairperson shall prepare agendas the second workshop and teleconferences. Each Panelist shall read and review the LECsR model and Draft LECsR model Documentation independently, and then the Panelists shall collaborate with the Chairperson to develop the Peer Review Reports. The Chairperson shall coordinate all the activities and products of the Panel. The Chairperson shall be the editor of the Peer Review Reports and shall compile and reconcile the contributions from the other Panelists.

The Draft LECsR model Documentation will be delivered to the Panel for review at the start of this Purchase Order. During the second workshop, the District will provide answers to the questions submitted by the Panelists and the public. Following submittal of the Draft Peer Review Report, the District will respond to the Panel's report. The complete Final Peer Review Report shall be included in the Final LECsR model Documentation as an appendix.

Work Breakdown Structure

Tasks for Panel

Task 1. Receipt of materials and Kick off Meeting

The Panelists shall acknowledge that they have read the SOW and agree to the terms therein along with receipt of the following:

Draft LECsR model Documentation entitled “Lower East Coast Subregional MODFLOW Model (LECsR model) "

Reference documents.

Panelist shall contact project managers Hope Radin and Laura Kuebler via email within two days of receiving materials. The Panelist shall bring a signed and dated acknowledgment form to kick off meeting.

Panelist shall attend kick off meeting. The meeting will be held at the SFWMD headquarters in West Palm Beach. During the meeting, staff shall conduct an overview of the LECsR model. Staff will explain Sunshine laws and use of Web Board. A review of the SOW and the responsibilities of the panel will be conducted. During this meeting, staff can answer general questions about LECsR model and MODFLOW packages that the SFWMD has modified. The District may elect to offer a tour of the model area in the afternoon (this is tentative). The meeting is open to the public and time will be set for public comment.

The Panelists shall conduct initial review of the LECsR model prior to the kickoff meeting. The Panelists shall read the Draft LECsR model Documentation along with selected background documents. Model input datasets shall be provided and the District shall provide answers to any questions related to the input files. Additional Background materials are listed in Attachment D. The background materials are provided so the Panelists may become familiar with the modeling area and the applications that have been used in creating the model. The background material is provided only as informative reference material; it is not under review and is not mandatory for the review of the model. Some of the background material will be provided in the form of links to PDF files on the District’s web site, links to other web sites, CDs (compact discs) or DVDs (digital versatile discs).

Deliverable 1A: Acknowledge of receipt of materials by contacting the Project Manager via email within two business days of receiving the materials. Signed form should be submitted at kick off meeting.

Due Date: Two business days of receiving the materials. Signed form should be submitted at kick off meeting.

Deliverable 1B: Panelists shall travel to West Palm Beach and actively participate in the workshop. “Active participation” is defined as: adhering to ground rules established by the workshop facilitator, attending all presentations, letting presenters know when any part of the presentation is not understood, be familiar with the District expectations for the Peer Review, and be ready to work within the schedule and through the logistics for the Peer Review. Personal appearance at workshop is required. No Panelist shall be allowed to attend via teleconference.

<u>Due Date:</u> Kick off Meeting will be scheduled prior to issuing P.O. (March 13)

Task 2. Initial review and questions for District staff

The Panelists shall provide questions to be considered by District staff in preparation for the second workshop (using the format listed in Table 2). The initial review is an opportunity for the Panel to identify aspects of the model that may not be clearly or fully covered in the documentation. From the Panel's standpoint, the purpose of these questions is primarily to address uncertainties and ambiguities that exist within the Draft LECsR model Documentation. The initial review shall also allow the Panel to begin drafting the Draft Peer Review Report for Task 4. The Panel shall prepare questions in advance of the second workshop so that the District can provide clarification during the workshop. The Panelists shall develop specific and general questions regarding items in the Draft LECsR model Documentation, and shall post these questions to the Web Board by March 20th. The Chairperson shall assemble and consolidate these questions into a single list to submit to the District via the Web Board and regular email by March 23rd. The Panelists' questions shall be organized by the Chairperson by Peer Review subjects, as defined in Table 2.

Table 2: Format for questions.

Major issues for discussion at workshop	
Minor issues requiring further clarification	
Typos and editorial comments in Document	To be provided on paper copy of document
Major strengths of model	

The Panel shall review the LECsR model documentation and provide comments and recommendations on, but not limited to, the following:

Model objectives, conceptualization, design, and assumptions made for input data sets).

Model documentation (explanation of model, data sources and assumptions).

Suitability of model for its intended applications.

Capabilities, limitations and future improvements

Comments are also sought regarding the overall structure of the Draft LECsR model Documentation, its readability of both text and illustrations (tables and figures), and its value as a comprehensive documentation of the LECsR model. In areas where the Panel identifies deficiencies, specific recommendations to resolve the deficiencies are required to facilitate revision of the document. The teleconferences may clarify the model documentation.

It is recognized that each member of the Panel shall comment most substantively on areas within their primary expertise, but comments are welcome on any aspect of the LECsR model Documentation. The Panel is asked not to comment on the MODFLOW source code. The Draft LECsR model Documentation shall be used as the primary basis of information on the structure, functions, processes, features, and capabilities of the LECsR model.

In addition to comments and recommendations, the Peer Review Reports shall include responses to the topic questions below. The responses by the Panel shall be stated in the most unambiguous manner possible. The Peer Review Reports shall address the topics in the questions below. The Panel may expand on these questions and topics during the workshop.

Topic Questions

Draft LECsR model Documentation:

Does the documentation provide a clear and appropriate description of the LECsR model?

Are the objectives of the documentation clear?

Are the objectives met?

Is the documentation readable? Are the figures clear?

Are additional levels of detail required to serve the intended objectives?

After reading the documentation, are you able to understand the purpose, scope, strengths, and limitations of the LECsR model?

Does the scope or format of the documentation need to be modified or expanded?

Model Implementation:

Based on the documentation and presentations provided by the District, are the modeling techniques and methodologies used in the LECsR model appropriate for the temporal and spatial scale of the model?

Is the conceptual model defensible?

Physical and Hydrologic Processes

Does the LECsR model include all the important physical and hydrological processes necessary to address subregional-scale water resource issues in south Florida?

Are the physical features and hydrologic processes represented adequately? (examples of physical features and hydrologic processes include:

Groundwater Flow

Flow in and through the Wetland system

Climatic Input

Boundary Conditions

Applied Stresses

Topography

Surface Water / Groundwater Connections (e.g. Canals, Wetlands)

Model Calibration:

Does the model appear to be adequately calibrated relative to other commonly employed calibration methods?

Are there any other calibration criteria or methods that you would recommend be used?

Is additional sensitivity analysis needed for the intended purpose of the model?

Are the verification methods appropriate?

Does there appear to be any model bias throughout range of model predictions?

Overall appropriateness of model

What are the model strengths?

What are the weaknesses of the model?

Are there any deficiencies in the model?

Is the model suitable and defensible for the applications detailed in the documentation?

Deliverable 2A A list of initial questions and concerns from each Panelist submitted to the Web Board no later then due date. Questions shall be based on review of Draft LECsR model Documentation and any teleconferences.

Due Date: March 20th

Deliverable 2B For the Chairperson only – a list of the single set of questions from the Panel submitted to the Web Board two weeks prior to the workshop based on Panel's initial review of the Draft LECsR model Documentation and any teleconferences. This list shall also be mailed to the Project Manager two weeks prior to the start of the workshop.

Due Date: March 23rd

Task 3A. Participate in Public Workshop

The public workshop will last one day (9:00 am to 5:30 pm). All portions of the meeting are open to the public. The workshop will also provide District's responses to the questions submitted by the Panel and will serve to clarify any issues raised by the Panel based on their initial review of the Draft LECsR model Documentation. The agenda for the workshop will be developed through consultation between the District and the Chairperson. The Chairperson shall post a Draft agenda on the Web Board one week prior to the start of the workshop. Final comments to the agenda shall be posted to the Web Board no later than two business days prior to the start of the workshop. The Project Managers will provide a final agenda by March 31st. The agenda will include, at a minimum, the following items:

District presentation covering Introductions, Review of Sunshine Rules, Meeting Logistics.

District presentation of written responses for the questions submitted by the Panel under Task 2 and discussion.

Question-and-answer session between the Panel and District modelers.

Discussion of expectations of the District for the Draft Peer Review and Final Peer Review Reports.

Panelists' discussion of model, outline for Draft Peer Review Report and distribution of work; discussion led by Chairperson.

Review of schedule and logistics for the Draft Peer Review Report.

Time allocated for comments from the public.

The District will take minutes of the workshop and will post the minutes to the Web Board within one week of the workshop. The workshop will be conducted between the hours 9 am – 5:30 pm, with up to one hour break for Lunch (Lunch is not provided during the workshop).

The workshop date will be finalized prior to execution of purchase order. Panelists will be selected from experts whom are available for the workshop date.

The District will schedule a teleconference to take place within a week after workshop to answer any additional questions that the panel may have for the District.

Task 3 Deliverables: -

Deliverable 3A.1. The Chairperson shall work with the District to develop the agenda for the workshop. The Chairperson shall post the Draft agenda one week prior to the start of the workshop. The District will post Final comments on the agenda no later than March 31st

Due Date: March 23rd

<u>Deliverable 3A.2.</u> Panelists shall travel to West Palm Beach and actively participate in the workshop. "Active participation" is defined as: adhering to ground rules established by the workshop facilitator, attending all presentations, letting presenters know when any part of the presentation is not understood, be familiar with the District expectations for the Peer Review, and be ready to work within the schedule and through the logistics for the Peer Review. Personal appearance at workshop is required. No Panelist shall be allowed to attend via teleconference.

<u>Due Date</u>: April 4th.

Task 3B. Teleconferences

The District will set-up weekly teleconference locations at District Headquarters, arrange for call-in numbers and publish teleconference dates and times in Florida Administrative Weekly (FAW).

Panelists shall attend teleconference meetings set up by District.

<u>Deliverable 3B.</u> Panelists shall actively participate in teleconference meetings. The District will set up times and dates for weekly meetings. The Chairperson shall post agendas for teleconference on Web Board at least 24 hours or one business day prior to call. Panelists will receive a call-in number and the public may listen and have an opportunity for public comment. The Chairperson shall determine if each meeting is needed or if it needs to be canceled (three weeks notice is required for cancellations). Additional meetings may be added upon three weeks notice to the District. No teleconferences will occur prior to kick off meeting.

<u>Due Date:</u> Weekly -as scheduled.

The District will take minutes of the teleconferences and will post the minutes to the Web Board.

Task 4. Develop Draft Peer Review Report

Panelists shall collaborate with other Panelists in writing a Draft Peer Review Report for the LECsR model. The Chairperson shall be the editor of this report. The Chairperson shall coordinate all the activities of the Panel to this end. Panelists shall provide their products to the Chairperson in a timely fashion closely following the review schedule developed during the workshop. Panelists shall be contributors to the Peer Review Report.

The Draft Peer Review Report shall include a summary, conclusions and recommendations. The Peer Review Report shall include specific recommendations for improvements in the model, as well as providing responses to topic questions posed in this SOW. The questions posed by the Panel in Task 2, at the workshop and from Web Board will be answered by District staff in a question/answer format (some questions will be answered only in writing) and be an appendix to the Draft Peer Review Document. The Peer Review Report shall include minutes from the public workshop as an appendix. The Peer Review Report shall also summarize the key points made during the workshop.

The Draft Peer Review Report shall at minimum include the following sections (section names can be modified)

Introduction

Model Conceptualization And Design

Comments On Methodology Of Creating Model Input Datasets

Comments on Representation of Hydrologic System.

Calibration And Verification

Calibration Sensitivity Analysis

Comments On Draft LECSR Model Document

Responses To Specific District Questions (Stated Above In Section **5.1.2.1**)

Overall Findings And Recommendations

Appendices

Scope Of Work For Peer Review

District's Answers To Questions By Panel.

Workshop Questions And Answers (In Question And Answer Format) (Provided By The District)

Panelists Answers to Topic Questions.

Minutes From All Meetings (Provided By The District)

The Peer Review Report shall use a Microsoft Word template (for styles and formatting) provided in Attachment C. Questions regarding the use of the template should be addressed to Dawn Rose (drose@sfwmd.gov)

The Draft Peer Review Report shall display line numbers for each page and display page numbers. (See page set up layout options in Microsoft Word)

Panel concurrence on each topic is strongly recommended. In the event that differences of opinion cannot be reconciled by the Chairperson, then they may be reported as such or as minority opinions.

Deliverable 4. Deliver the Draft Peer Review Report. Provide comments and recommendations based on the review of the Draft LECsR model Documentation. The Chairperson shall coordinate, collect, and consolidate the individual comments, conclusions, and recommendations by the Panel. The report shall be written in Microsoft Word and posted to the Web Board and emailed to the Project Managers. The Panel shall answer in the most unambiguous manner the questions posed by the District under Task 2.

Due Date: Panelists shall post their comments to Web Board. Panelists; comments are due, April 26th

The Chairperson shall post the consolidated Draft Peer Review Report to the Web Board May 3rd, send and email a copy to Project Managers and mail a hard copy to the District.

In the event that Panelists have follow-up questions that arise after the second workshop, the questions will be addressed at teleconferences. Questions should be submitted via the Web Board at least 2 business days prior to teleconference. (Only those questions that are posed to the District at workshop and the teleconference that occurs one week after workshop need to be included in final peer review document)

DISTRICT REVIEW:

The Project Manager will provide the Chairperson with District's staff draft response of the Draft Peer Review Report. This review will clarify any misunderstandings and identify factual errors and will be delivered to the Chairperson via the Web Board. District staff will answer Panelists questions that have been submitted to the board.

Staff comments will be posted to Web Board on or prior to May 19th

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Task 5. Final Peer Review Report

The Final Peer Review Report is the primary product of this p.o. The Panel shall work collaboratively to produce the Final Peer Review Report based on the Draft Peer Review Report, any new information received during the workshop, and any other information received from the District. The Chairperson shall seek consensus among the Panelists. Each Panelist is responsible for cooperating with the Chairperson in the development of the Final Peer Review Report. The Chairperson is responsible for coordinating and delivering the Final Peer Review Report. All Panel interaction for the development of the Final Peer Review Report shall continue to be conducted through the Web Board and posted teleconferences. The Final Peer Review Report shall be posted to the Web Board.

Deliverable 5: The Chairperson shall post to the Web Board and email a Final Peer Review Report, using the Microsoft Word Template provided for fonts and styles. The Peer Review Report shall meet all the criteria listed in Tasks 1 through 4. A signed hard copy shall be mailed to the District.

Due Date: Panelists shall post their comments to the Web Board no later than May 30th. Chairperson shall post the Final Peer Review Report on or prior to June 2nd and mail a signed copy to the District.

Any requests for time extension shall be made by the Chairperson to District Project Managers. Project Managers will post approval/denial to Web Board. June 2nd is a fixed deadline so any changes in dates of other tasks can not result in changing the final deadline.

Duties and Tasks of District

The Requesting Division is the Resource Evaluation and Subregional Modeling Division, of the District's Water Supply Department. District will perform the following duties:

Select Chairperson and Panelists.

Send background materials to Panelists.

Finalize workshop agenda received from Chairperson.

Handle logistics for the workshops and teleconferences.

Set up dates and times for all teleconferences.

Take minutes of all meetings (Workshops and Teleconferences)

Respond to Panelists' questions and comments at the Workshop and Teleconferences.

Monitor Web Board

Review and evaluate the Draft and Final Peer Review Reports.

The Requesting Division is the Resource Evaluation and Subregional Modeling Division, of the District's Water Supply Department.

The Draft LECsR model Documentation and internet paths to background materials will be delivered to each Panelist by District staff.

Kick off Meeting. – District will set up agenda, presentations and possibly short tour.

District staff will be available to answer questions that the Panelist may have in order to clarify any area of concern that he/she does not understand. Questions should be posted on the Web Board. Staff will reply via the Web Board, by workshop date (April 4^{th}) and at teleconferences.

Staff will provide support to the Panel during the Workshops.

Chairperson should inform District personnel what technical assistance they anticipate needing prior to workshops.

Staff will set up, maintain and monitor Web Board.

Staff will set up workshop follow up teleconference. (Including time and date).

Staff will set up teleconference meetings (after Chairperson selects times).

Staff will review deliverables.

Staff will organize the April 4th workshop in cooperation with the Chairperson.

Staff will prepare a draft response to the Draft LECsR model Peer Review Report, and will produce a response at the conclusion of the Peer Review.

The District agrees to perform its duties within the timeframes of this Statement of Work.

Evaluation Criteria for Acceptance of Deliverables

Task 1. Acceptability for the Task 1A deliverable is acknowledgment receipt of review materials and signing off on scope of work.

Acceptability for Task 1B is active participation in the Kick off Meeting. Panelists must attend in person.

Task 2. Acceptability for the Task 2A deliverable is the timely submittal of comments and questions to Chairperson. The Panel's questions, concerns and information to the District should reflect thoughtful reading of the documents provided.

Acceptability for the Task 2B deliverable is the timely submittal of a compiled and sorted list of comments and questions to the District from the Chairperson.

Task 3. Acceptability of the Task 3A.1 is the timely submittal of agenda by Chairperson.

Acceptability of the Task 3A.2 is active participation in the workshop.

Acceptability of Task 3B is active participation in the teleconferences by panel members and chairperson and timely submittal of agendas by Chairperson.

Task 4 Acceptability of the Task 4 deliverable will be based upon whether the Draft Peer Review Report reflects a thoughtful and substantive evaluation of the LECsR model. The Draft Peer Review Report shall include explicit responses to the topic questions listed in Task 2 above and include constructive steps to be taken to correct any deficiencies identified by the Panel. The document shall include the District's answers to questions for the Panel and Public. The Draft Peer Review Report shall also summarize the key points made during each session of the workshops.

Task 5 Acceptability of Task 5 will be the submittal of the Final Peer Review Report, representing a consensus view of the entire Panel. The Final Panel Peer Review Report shall respond to all the questions posed in Task 2 and to additional questions or issues raised in workshops. The Report should be completely objective in its evaluation and written so that it can be understood, defensible and understood by a broad audience.

Payment for Services

The Panelist must provide a cost for each item in Table 3. Upon satisfactory completion of all services required, the Panelists will be paid at an hourly rate which shall include all labor and expenses. Panelists are responsible for making and paying for their own travel and meal arrangements. The unit rate for each Task in Table 3 should include the costs incurred for travel, meals, phone calls, overhead, etc.

A summary deliverable schedule for each task associated with this project is set forth below (Table 3). All deliverables submitted hereunder are subject to review by the District and outside agencies. However, the District will be responsible for coordinating project direction, including Final approval of all project deliverables.

The Chairperson hereby agrees to provide the District all deliverables described in the Statement of Work in Microsoft Word. Acceptability of all work will be based on the judgment of the District that the work is technically defensible, accurate, precise, and timely.

After issuance of the purchase orders**:** payment will be made following receipt and acceptance by the District of project deliverables in accordance with the schedule set forth below. Payment by the District for all work completed herein will not exceed the TOTAL in the table below.

The purchase order will be executed for and will be paid from fiscal year 2006 funds.

Table 3: Schedule of Deliverables and Rate Schedule

Task No.	Deliverables	Due Date	Due Date	Estimated Hours		Unit cost	Task Cost	Payment
		Panelist	Chair-person	Panelist	Chair-person			
Task 1a	Acknowledge-ment of Materials	March 9	March 9					
Task 1b:	Kick off meeting/ tour* (tour not finalized)	March 9	March 9	8	8	$___	$___	
Task 2	Questions for District	March 20	March 23	40	50	$___	$___	$____ (10%)
Task 3A.1	Draft agenda		March 23		4		$___	
Task 3A.2	Attend workshop	April 4	April 4	8	8	$___	$___	
Task 3B	Attend teleconferences Chairperson prepares agendas for teleconferences	Weekly.	Weekly.	18	25	$___	$___	$_______ (40%) ~April 11
Task 4	Draft Peer Review Report District comments on Draft	April 26	May 3 May 19	40	60	$___	$___	

Task 5	Final Peer Review Report	May 30	June 2	20	40	$___	$___	$______(50%)
			TOTAL	134	195	$___	$___	$_______

The Panelist should submit invoices to the Project Managers for approval upon completion of Task 2, one week after second workshop (April 11) and upon completion of deliverables.

Reference

Giddings, J.B., L. Kuebler, J. Restrepo, K. Rodberg, A. Montoya, H. Radin, The Lower East Coast Subregional MODFLOW Model Documentation 2006 (*forthcoming)*, Resource Evaluation and Subregional Modeling Division, Water Supply Department, SFWMD, West Palm Beach FL,

Glossary - Definition of Key Terms

Key terms have been defined to aid in the readability of this Statement of Work. These terms are:

Chairperson Panelist who shall lead the Panel in the Peer Review of the LECsR model.

District South Florida Water Management District.

District Headquarters 3301 Gun Club Road, West Palm Beach, FL 33406

Documentation

Draft LECsR model Documentation of the LECsR model to be Peer Reviewed.

Final LECsR model Documentation of the LECsR model after consideration of the Final Peer Review Report from the Panel.

EMAIL Addresses Addresses to be used by Chairperson to submit panel products to the District. hradin@sfwmd.gov, lkuebler@sfwmd.gov

FAU Florida Atlantic University

Kick off Meeting A public meeting of the Panel to be held in West Palm Beach, Florida. Personal attendance of Panel members is required. Presentations will be given by the District. The public may ask questions during the public comment session.

LEC Lower East Coast

LECsR model The Lower East Coast Subregional MODFLOW Model is a subregional model implemented by the District and FAU and applied by the District.

Mailing Address Resource Evaluation and Subregional Modeling Division, Water Supply Department, Mail Code 4330, South Florida Water Management District, P.O.B. 24680, West Palm Beach FL, 33416-4680

Model Implementation Model Conceptualization and Development, using previously documented modeling code - for example MODFLOW. LECsR model is the implementation of a MODFLOW model for the Lower East Coast of Florida.

MODFLOW A modular three-dimensional finite difference groundwater flow model developed by the United States Geological Survey.

Panel The Peer Review Panel, a group of three experts (2 Panelists and 1 Chairperson) assembled to Peer Review the model and model documentation of the LECsR model.

Panelist A member of the Peer Review Panel.

Project Managers Hope Radin Staff Hydrogeologist, Phone: (561) 682-2120, email: hradin@sfwmd.gov and Laura Kuebler Staff Hydrogeologist, Phone: (561) 682-2815 email: lkuebler@sfwmd.gov are the project managers for the District.

Peer Review Reports

Initial Questions Questions and comments submitted prior to workshop.

Draft Peer Review Report Peer review document prepared by Panel to be submitted to the District for response and clarification.

Final Peer Review Report Peer review document prepared by Panel to be submitted to the District as the Final product of the Peer Review.

Regional model Terminology used by the District to describe a numerical model with a low spatial resolution (An example of a Regional model is the SFWMM which has 2 mile by 2 mile grid spacing).

SAS Surficial Aquifer System.

SFWMM South Florida Water Management Model is the regional-scale model developed and applied by the District (cell resolution is 2 miles by 2 miles).

Subregional model Terminology used by the District to describe a numerical model with a higher spatial resolution than that of the SFWMM. (An example of a Subregional model is the LECsR model, which has a cell resolution of 704 feet by 704 feet)

Teleconference A phone meeting of Panelists. The time and dates will be posted and members of the public can listen to the call at a conference room at the District.

Web Board An Internet site implemented by the District and accessible to the public at http://WebBoard.sfwmd.gov:8080/~gwpeerreview.

To be used a**s r**epository for all draft/final chapters and versions of Peer Review Report and agendas for the workshop and teleconference. Under Florida's Sunshine Law, it is mandatory that all communications between two or more Panelists occur in a forum open to the public, therefore no discussions between Panelists can occur on Web Board. Data may be posted and read by members of the board, District staff as well as the public. Anyone experiencing difficulty in accessing the Web Board should contact the Web Board administrator. Discussions on posted items shall occur during teleconferences and workshop.

Web Board Administrator Trudy Morris will assist anyone with difficulties posting or reading Web Board messages Phone (561) 682-6569, email: tmorris@sfwmd.gov

Workshop A public meeting of the Panel to be held in West Palm Beach, Florida. Personal attendance of Panel members is required. Presentations will be given by the District to answer questions from the Panel and public. Panel shall discuss and work on Peer Review and tasks for Peer Review Reports.

Appendix A

Introduction and Background

The request for Peer Review pertains to the recently implemented Lower East Coast Subregional MODFLOW Model (LECsR model). The LECsR model is a subregional groundwater flow model with surface water capabilities, which represents the Surficial Aquifer System (SAS) in south Florida and covers roughly 7,500 square miles. The LECsR model is underlain by two aquifer systems: the SAS and the deeper Floridan Aquifer System. This study focuses on the SAS and encompasses nearly the entire system within the study area.

This model will be used to simulate the hydrogeology and management of the water resources system from Lake Okeechobee to Florida Bay and will provide a means of analyzing various planning and management scenarios, which support South Florida Water Management District (District) goals. Florida Atlantic University (FAU) implemented the LECsR model in cooperation with the District using the standard United States Geological Survey (USGS) MODFLOW-96 code along with customized District modules. The customized modules allow additional hydrologic processes (e.g., Over land flow, surface water/ groundwater interactions in wetlands) to be incorporated into the model and provide the ability to add complexity to the model.

Previously, five county-wide, sub-regional models (North Palm Beach, South Palm Beach, Broward, North Miami-Dade and South Miami-Dade) were applied. Originally, these subregional models addressed county-level problems and the knowledge base was specific to each county and its water resources. In order to simulate the majority of the Lower East Coast (LEC) planning area, the county-specific subregional models were modified, updated, and combined into one model, the LECsR model. Additional areas simulated by LECsR model but not included in the county-wide, sub-regional models are the Everglades Agricultural Area (EAA) and Everglades National Park (ENP). The hydrogeologic components in the LECsR model include, but are not limited to, evapotranspiration (ET), recharge, canal/aquifer interaction, water supply and environmental restoration demands, wetland overland and river flows, and water diversions by pumping or gravity.

The model should be able to routinely handle hydrologic changes such as: ongoing modifications to pumpage data sets representing new allocations as well as projected future demands, ongoing modifications to canal and wetland stages and/or modifications at model boundaries in order to take into account proposed water supply improvements, and ongoing changes in land use which may differ considerably from those inherent to the calibration period of record.

Documentation of the LECsR model consists of:

Explanation of the model objectives, conceptualization and design.

Explanation of the model calibration, verification, and sensitivity analysis.

Explanation of how the model is going to be applied.

Discussion of the capabilities, limitations, and future improvements of the model.

Model Applications

The application of the LECsR model involves considering four principal resource management initiatives, which include water supply planning and restoration, design evaluation, water resource rulemaking and consumptive use permitting as outlined herein:

In water supply planning, forecasted water demands and potential water supply scenarios are represented in the model to formulate recommendations for developing water resources. Scenarios can include comparisons of a planned alternative to current conditions or to other alternatives. In addition, the model may support the Comprehensive Everglades Restoration Plan (CERP) projects which include Everglades and environmental restoration. Water Reservations projects may include scenarios that will evaluate tributary flows to a river and watershed hydrology under current conditions.

In the area of design evaluation, specific structural features are simulated in the model (such as reservoirs and canal modifications) in order to evaluate potential benefits and impacts associated with the features.

In assessing new rules (e.g., Minimum Flows and Levels [MFL]), the hydrologic, environmental and economic effects of proposed rules on the water resources are evaluated using model results.

In the consumptive use permitting process, models are available to the public domain. The LECsR model will be available to both permit applicants, and to permit review staff who will use it in evaluating water supply withdrawal permit requests.

Given the importance of these ongoing initiatives, the District seeks a Peer Review of the developed model and the supporting documentation for quality assurance.

Attachment A

Draft Lower East Coast Subregional MODFLOW Model Documentation

Attachment B

Sunshine Rules

http://www.sfwmd.gov/org/erd/Web Board/sunshine.html#sunshine

Attachment C

Word Template for document fonts and files

Attachment D Background Material

SFWMD, The Lower East Coast Regional Water Supply Plan, May 2000

http://www.sfwmd.gov/org/wsd/wsp/lecwsp.htm

Power point presentation on LECsR model and District modules.

Description of the customized modules for Wetland, Utility Generation and

Diversion Packages can be found at: http://www.sfwmd.gov/org/pld/hsm/hsm.html

Attachment E-Optional Background Material:

The LECsR model input files (note files are very large) and output list file.

District MODFLOW-96 source code provided on request.

Restrepo, J.I. and J.B. Giddings. 1994. Physical Based Methods to Estimate ET and Recharge Rates Using GIS. In: *Effects of Human-Induced Changes on Hydrologic Systems*, American Water Resources Association, Bethesda, Maryland.